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OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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O.K.

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 33 APRIL 1911 NUMBER 4

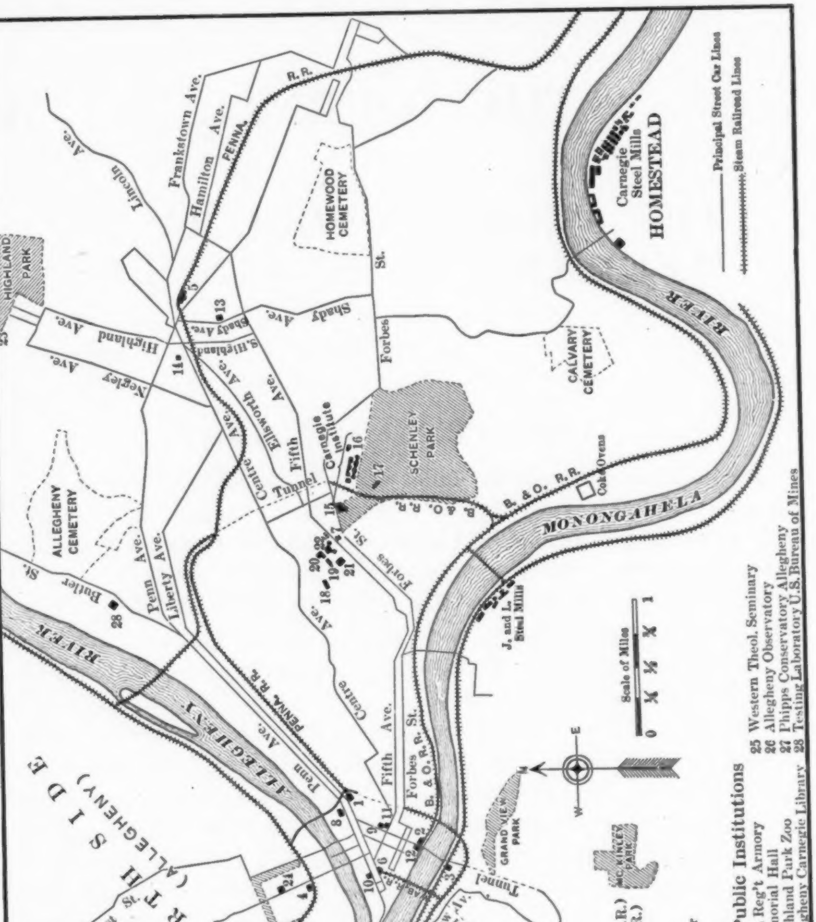
THE SPRING MEETING

Preparations are actively under way for the Spring Meeting to be held at Pittsburg, Pa., May 30 to June 2. The headquarters during the meeting will be at Hotel Schenley and the Society is fortunate in being able to arrange to hold its professional sessions at the Carnegie Institute which is in close proximity to the hotel and most attractive as a meeting place and rendezvous for such an occasion as this. Application for rooms should be made direct to the hotel and not through the local committee.

The Committee on Meetings have provided professional sessions of unusual interest and particularly adapted for an industrial center like Pittsburg. The first session for the presentation of papers will be on Wednesday morning on the subject of The Mechanical Engineering of Cement Manufacture, following which there will be an opportunity to visit the plant of the Universal Portland Cement Company through invitation of its President, E. M. Hagar. The special train to this plant will stop at East Pittsburg giving members an opportunity to visit the Westinghouse works. On Wednesday evening there will be a session on Machine Shop Practice at which the subjects of assembling small machine parts and the development of milling cutters will be discussed.

On Thursday morning the session will be very short with miscellaneous papers, after which an excursion on the river is planned. This will be one of the most delightful features of the entertainment and one in which everybody will wish to participate. In the evening will be the reception and dance.

On Friday morning there will be papers relating to steel works machinery with especial reference to blowing engines and forging


MAP OF
PITTSBURGH
Principal R.R. Stations
1 Union Station
2 Baltimore & Ohio
3 P. & L. E.
4 P. Ft. W. & C. (P.R.R.)
5 East Liberty (P.R.R.)
6 Wabash
Principal Hotels
7 Schenley
8 Fort Pitt
9 Duquesne
10 Lincoln
11 Henry
12 Monongahela
13 Kenmawr
14 Dorset
Principal Public Institutions
15 Carnegie Institute, Main Bldg.
16 Carnegie Inst. Technical Schools
17 Phipps Conservatory
18 19 20 University of Pittsburgh
21 18th Reg't Armory
22 Memorial Hall
23 Highland Park Zoo
24 Allegheny Carnegie Library
25 Western Theol. Seminary
26 Allegheny Observatory
27 Phipps Conservatory Allegheny
28 Testing Laboratory U.S. Bureau of Mines
Scale of Miles
Principal Street Car Lines
Steam Railroad Lines
NORTH SIDE
(ALLEGHENY)
ALLEGHENY RIVER
OHIO RIVER
MONONGAHELA RIVER
HOMESTEAD
Carnegie Steel Mills
J. and L. Steel Mills
SCHENLEY PARK
HIGHLAND PARK
RIVERVIEW PARK
GRAND VIEW PARK
McKINLEY PARK
ALLEGHENY CEMETERY
HOMEWOOD CEMETERY
CALVARY CEMETERY
HIGHWOOD CEMETERY
Carnegie Institute
Coke Ovens
Tunnel
PENNA. R.R.
B. & O. R.R.
WABASH R.R.
PENNA. LINES
Fifth Ave.
Forbes St.
Penn Ave.
Liberty Ave.
Centre Ave.
Ellsworth Ave.
Negley Ave.
Highland Ave.
Shady Ave.
Frankstown Ave.
Hamilton Ave.
Lincoln Ave.
Butler St.
East St.
Perrysville Ave.
Grand View Av.

presses. Friday afternoon will close the convention with excursions provided for that afternoon.

A session is also planned for the Gas Power Section, and in view of the fact that Pittsburg is a center of the natural-gas region and that many gas-power plants as well as producer plants have been installed in that vicinity, there will be a large attendance of engineers interested in this subject.

The manufacturers of Pittsburg have very generally extended invitations to their works and the Local Committee, E. M. Herr, Chairman, and E. K. Hiles, Secretary, have under way a program for entertainment which can best be described as one commensurate in every way with the wonderful opportunities of this great center.

Previous to this meeting the American Foundrymen's Association is to convene in Pittsburg and the exhibit of foundry appliances, under the auspices of the association, will be held over during two days of the meeting of The American Society of Mechanical Engineers.

There are many features and points of general interest aside from those connected with the industries which will be taken advantage of in the entertainment provided for the ladies and such members and guests as desire to attend. The International Art Exhibit at the Carnegie Institute will be open at this time, and it is probable an organ recital will be held at the institute.

RAILROAD TRANSPORTATION NOTICE

Arrangements for hotel, transportation and Pullman car accommodations should be made personally.

Special concessions have been secured for members and guests attending the Spring Meeting in Pittsburg, May 30 to June 2, 1910.

The special rate of a fare and three-fifths for the round trip, on the certificate plan, is granted when the regular fare is 75 cents and upwards, from territory specified below.

a **Buy your ticket at full fare for the going journey, between May 26 and June 1 inclusive. At the same time request a certificate, *not a receipt*. This ticket and certificate should be secured at least half an hour before the departure of the train.**

b **Certificates are not kept at all stations. Ask your station agent whether he has certificates and through tickets. If not, he will tell you the nearest station where they can be obtained. Buy a local ticket to that point, and there get your certificate and through ticket.**

c On arrival at the meeting, present your certificate to S. Edgar Whitaker, office manager at the Headquarters. A fee of 25 cents will be collected for each certificate validated. No certificate can be validated after June 2.

d An agent of the Trunk Line Association will validate certificates, May 31, June 1, 2. No refund of fare will be made on account of failure to have certificate validated.

e One-hundred certificates and round trip tickets must be presented for validation before the plan is operative. This makes it important to show the return portion of your round trip ticket at Headquarters.

f If certificate is validated, a return ticket to destination can be purchased, up to June 6, on the same route over which the purchaser came, at three-fifths the rate.

The special rate is granted only for the following:

The Trunk Line Association:

All of New York east of a line running from Buffalo to Salamanca, all of Pennsylvania east of the Ohio River, all of New Jersey, Delaware and Maryland; also that portion of West Virginia and Virginia north of a line running through Huntington, Charleston, White Sulphur Springs, Charlottesville, and Washington, D. C.

Hotel Rates for Spring Meeting at Pittsburg

Minimum Rates

	Without Bath			With Bath		
	Single Room	Single Room Two Persons	Double Room Two Persons	Single Room	Single Room Two Persons	Double Room Two Persons
Hotel Schenley	$2.00	$3.00	$—	$3.00	$4.00	$5.00
Fort Pitt Hotel	1.50	—	2.50	2.50	—	3.50
	2.00	—	3.00	5.00		7.00
Hotel Henry	1.50	2.50	3.00	2.50	3.50	4.00
	2.00	up	up	up	up	up
Monongahela House	1.50	—	2.00	2.50	—	4.00
	2.00		3.00	3.00		5.00
Hotel Anderson	1.00	1.50	3.00	2.50	—	4.00
		2.00	4.00	3.50		
Duquesne Hotel	1.50	—	2.50	2.50	—	3.50
Hotel Lincoln	1.50	—	2.00	2.00	—	3.00
	2.50	—	4.00	3.00		5.00
Seventh Avenue Hotel	1.50	2.50	3.00	2.50	4.00	5.00
Colonial Annex Hotel	1.50	2.00	2.50	2.00	3.00	3.50
						5.00
The Dorset	1.00	—	2.00	2.00	—	3.00
Hotel Lorraine*	2.50	—	4.00	3.00	—	5.00
				3.50		6.00

*American plan.

MONTHLY MEETINGS

NEW YORK MEETING, APRIL 11

At a meeting of the Society in New York on April 11, agricultural machinery, and in particular the farm tractor, will be considered in a paper presented by L. W. Ellis, traction plowing specialist of the M. Rumely Company, La Porte, Ind., on the Economic Importance of the Farm Tractor. Mr. Ellis is expected to present his paper in person. Following the paper Dr. Charles E. Lucke, of Columbia University, will give a talk on the mechanical equipment of farm tractors, illustrated by views taken at the Canadian Industrial Exhibition held in Winnipeg, Manitoba, last summer.

BOSTON MEETING, APRIL 21

At the meeting of the Society in Boston on April 21, the Boston Section of the American Institute of Electrical Engineers and the Boston Society of Civil Engineers coöperating, a paper will be presented by B. R. T. Collins, with the Stone and Webster Corporation, Boston, on Oil Fuel for Steam Boilers. The paper deals with the possible use of oil fuel for steam generating purposes in the Atlantic coast states, its safety and permanency of supply, as well as conditions under which it may have special advantages over coal.

PHILADELPHIA MEETING, APRIL 22

A meeting of the Society will be held at the Engineers' Club in Philadelphia, on Saturday evening, April 22, at which the subject for discussion will be The Recent Work of the United States Fuel Testing Plant.

PAST MEETINGS

NEW YORK MEETING, MARCH 10

A meeting of the Society for the consideration of the subject of Industrial Power was held in New York on March 10, in which the American Institute of Electrical Engineers coöperated. Three papers were presented, two by John C. Parker, Mem.Am.Soc.M.E., general manager of the Parker Boiler Company of Philadelphia, Comments on

Fixed Costs in Industrial Power Plants, and Notes on the Cost of Electrical Energy; and a third, The Cost of Industrial Power by A. E. Hibner, Assoc.A.I.E.E., industrial engineer of the Toronto Electric Light Company of Toronto. N. T. Wilcox, Mem.A.I.E.E. and Chairman of the Industrial Power Committee of the institute, presided during the discussion.

Mr. Parker called attention, in the first of his papers, to the importance of capitalizing the cost of supervision and of proper insurance in predetermining the cost of electric power; and in the second gave an account of certain attempts to derive a general equation for the cost of power, without result. The three factors involved in every industrial power problem, namely, investment charges, operating charges, and cost of heating, were treated by Mr. Hibner, who argued that the small power user should take his problems to an independent consulting engineer before deciding whether he should build his own power plant or secure power from a supply company.

The papers were discussed by N. T. Wilcox; P. R. Moses, Mem. A. I. E. E., of New York; D. B. Rushmore, Mem. Am. Soc. M. E., of the General Electric Company, Schenectady, N. Y.; R. P. Bolton, Mem.Am.Soc.M.E., of New York, Arthur Williams, Mem.A.I.E.E., of the New York Edison Company, New York; Parker H. Kemble, Mem.Am.Soc.M.E., of the Edison Illuminating Company of Brooklyn; H. H. Edgerton of New York; C. M. Ripley, Assoc.A.I.E.E., New York; George L. Fowler, Mem.Am.Soc.M.E., of New York. Written discussions were contributed by H. W. Peck, Assoc. Am.Soc.M.E., of the Rochester Railway and Light Company, Rochester, N. Y.; John H. Norris, Mem.Am.Soc.M.E., of the National Meter Company, Brooklyn; R. H. Tillman, Assoc.A.I.E.E., of the Consolidated Gas Electric Light and Power Company of Baltimore; Walter S. Timmis, Mem.Am.Soc.M.E., of New York; Stonewall Tompkins, Mem.Am.Soc.M.E., chief engineer of the Coney Island and Brooklyn Railroad Company of Brooklyn; F. G. Gasche, Assoc.A.I.E.E., mechanical engineer of the Illinois Steel Company of South Chicago; William B. Jackson, Life Member Am.Soc.M.E., of Chicago; and Rudolph Tschentscher, superintendent and electrical engineer of the Illinois Steel Company of South Chicago.

SAN FRANCISCO MEETING, MARCH 10

A meeting of the Society was held in San Francisco, on March 10, which supplemented the meeting of December 16, 1910, at which the

subject of Pacific Coast Practice in the Use of Crude Petroleum was considered in a series of eight papers, covering various phases of the topic. An additional paper, Locomotive Practice in the Use of Fuel Oil, by Howard Stillman, mechanical engineer and engineer of tests with the Southern Pacific Company, was presented, and the meeting thrown open for general discussion. Among those who participated were G. W. Dickie, E. J. Dyer, W. F. Durand of Stanford University, Thomas Morrin, and Messrs, Berry and Yeatman.

BOSTON MEETING, MARCH 17

At a meeting of the Society held in Boston, March 17, the Boston Society of Civil Engineers and the Boston Section of the American Institute of Electrical Engineers coöperating, a paper on Speed Regulations in Hydro-Electric Plants by W. F. Uhl was presented. This paper deals with the inefficiency of well designed governors on turbine units to obtain satisfactory speed regulation and gives formulae and tables for calculating it on open-flame and encased turbines. It was discussed by W. G. Starkweather, Mem.Am.Soc.M.E., of the Wheeler Condenser Co., R. S. Hale, Mem.Am.Soc.M.E., of the Essex Water Power Co., H. E. Lawrence of the Lombard Governor Co., F. M. Gunby, J. W. Cooke of the Electric Storage Battery Company, T. S. Bedford of the Electric Storage Battery Company, F. N. Connett, of the Builders Iron Foundry Co., E. A. Ekern of the Stone and Webster Engineering Corporation.

CONDENSED CATALOGUES OF MECHANICAL EQUIPMENT

The first division of a collection of Condensed Catalogues of Mechanical Equipment is published in this issue of The Journal. The purpose of the Condensed Catalogues is to furnish a concise statement of the salient features of the product of manufacturers of mechanical equipment, the statement comprising a condensation from manufacturers' catalogues of such facts as are most likely to be required by engineers and machinery users for purposes of preliminary reference; as for instance, tables of dimensions, sizes and capacities, brief mention of distinctive features and special adaptations.

For convenience of reference the Condensed Catalogues are being published in trade divisions, commencing with Power Plant Equipment in this issue. Other divisions to be included in subsequent

issues are Hoisting and Conveying Machinery; Power Transmission; Machine Shop and Foundry Equipment; Pumping Machinery, Mining and Metallurgical Equipment; Rolling Mill Equipment; Heating and Ventilating Apparatus; Refrigerating Machinery.

It is desired to make this feature of The Journal a helpful adjunct to the working library of engineers and machinery users; and suggestions in regard to possible improvement of the form and matter of the catalogue pages are invited. It is believed that in undertaking the publication of this collection of standardized catalogue data The American Society of Mechanical Engineers is rendering a service to its membership and to the engineering profession as a whole.

STUDENT BRANCHES

ARMOUR INSTITUTE

The Armour Institute Student Branch held a regular meeting, March 22, at which Paul M. Bird, Mem. Am. Soc.M.E., read a paper on The Prevention of Smoke.

BROOKLYN POLYTECHNIC INSTITUTE

On March 4 at a meeting of the Polytechnic Institute Student Branch, Vinton Smith gave an interesting lecture on Efficiency-Engineering, following the business of the evening. On the afternoon of March 4 an excursion was made to the Thompson Lovelace Aeroplane Factory with 27 in attendance.

COLUMBIA UNIVERSITY

At a meeting of the Columbia Umiversity Student Branch on February 15, Edwin H. White delivered a lecture on The Art of Welding and Cutting Metals by Means of the Oxy-Acetylene Blow-Pipe, and illustrated his talk with practical use of the blow-pipe. On March 3 a meeting of the Executive Committee was held at which plans for future meetings of the branch were discussed.

CORNELL UNIVERSITY

On February 15 Prof. R. C. Carpenter, Mem.Am.Soc.M.E., outlined in a paper to the Student Branch of Cornell University the history of The American Society of Mechanical Engineers, its organization, aims, etc., and its relation to its student members.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Student Branch of the Massachusetts Institute of Technology held its annual meeting at the Boston City Club, March 14, 1911. The result of the election of officers was as follows: J. A. Noyes, Chair-

man, R. B. Brownlee, Vice-Chairman, R. M. Ferry, Secretary, A. F. Kenrick, Treasurer, and D. H. Carpenter, E. W. DeWitte and L. L. Custer, Governing Committee. The guests and speakers of the evening were Gaetano Lanza, Honorary Chairman of the Student Branch, Calvin W. Rice, Secretary of the Society, Dugald C. Jackson, President A.I.E.E., and members of the Committee on Meetings of the Society in Boston. In brief the speakers pointed out the benefits to be derived from taking an active part in Society affairs by presenting papers and participating in the discussion of others read before its meetings. This would give the student a training he would find invaluable in later life. Coöperative meetings with a view to broadening ones training were also strongly emphasized.

At the meeting, March 7, Henry Cave spoke on the subject of Oxy-Acetelene Welding and Cutting of Metals. Mr. Cave's talk was illustrated by a large number of lantern slides and was concluded with a practical demonstration of the process. The civil, electrical and mining student societies were invited to attend the meeting, bringing the attendance up to 140.

MISSOURI UNIVERSITY

On March 5 at a meeting of the Missouri University Student Branch, The Economic Importance of the Farm Tractor by L. W. Ellis was presented by F. T. Kennedy. This was followed by discussion by Prof. H. W. Hibbard, Prof. E. A. Fessenden and Messrs. Wharton, Staph and Westcott.

OHIO STATE UNIVERSITY

On February 18 the newly organized Ohio State University Student Branch met at the home of Professor Magruder to act on a report of the Committee on Constitution and By-Laws. Nineteen student members were present and also Professors Hitchcock, Judd and Sanborn and H. H. Bailey. After the business of the meeting Professor Magruder gave an historical account of the Society and urged that the members of the Student Branch affiliate themselves with the Society as Juniors after graduation.

The regular monthly meeting was held February 28 when a paper on the Humphrey Gas Pump was read by E. F. Biggert which was followed by an open discussion. Professor Hitchcock gave an interesting account of the leading technical schools of the Middle West and said that the mechanical engineering laboratory of the Ohio State

University compared favorably with any of them. L. E. Allen and I. H. Pohlman were announced as speakers for the next meeting.

PURDUE UNIVERSITY

At a meeting of the Purdue University Student Branch, February 23, Prof. G. A. Young, Mem.Am.Soc.M.E., read a paper on The Story of a Self-Igniting Engine. The subject covered the experience of Professor Young in testing and obtaining the patent of a new self-igniting gas engine.

At the meeting of the Student Branch on March 8, O. H. Day, Purdue, 1909, of the Rumley Tractor Company, La Porte, Ind., read a paper on The Application of the Internal-Combustion Engine to Farm Tractors.

STANFORD UNIVERSITY

On March 1 at a meeting of the Stanford University Student Branch, Mr. Percy of San Francisco, a representative of the Standard Oil Co., gave an illustrated talk on Oil Burning and Burners.

STEVENS INSTITUTE OF TECHNOLOGY

On February 27 at a meeting of the Stevens Institute of Technology Student Branch, a paper by Herbert Agnes on Hydro-Electric Power Plants was read. The paper was introduced by a general consideration of the present development in this field and possible future sources of power as indicated in the report of the U. S. Geological Survey. The various elements that go to make up this class of engineering and the various difficulties to be encountered were also described. Several slides were introduced showing the locations of the various plants, views of some of them, the turbines, generators, etc. The success and the limitations together with an analysis of the costs of generating hydro-electric power were touched upon. Mr. Bauhan, who discussed the paper, described in great detail the various methods and devices for securing continuous services.

At the March 16 meeting a paper on Railway Signals in American Practice by Arthur F. Requa was presented and illustrated with lantern slides. The topics treated in the paper were the direct-current systems as applied to steam roads and the alternating systems as applied to direct-current and alternating-current electric roads. In conclusion views of signaling apparatus were shown and fully explained.

UNIVERSITY OF ARKANSAS

At a meeting of the University of Arkansas Student Branch Prof. B. Mitchel presented a description of the Allis-Chalmers factory at New Allis, and W. B. Gardner read a paper on the Raising of the Maine.

UNIVERSITY OF CINCINNATI

On February 24 a paper on Radial Drills was read by H. M. Morris, Mem.Am.Soc.M.E., before the University of Cincinnati Student Branch.

UNIVERSITY OF ILLINOIS

On March 3 at a meeting of the University of Illinois Student Branch, F. N. Keown discussed the paper by John Calder on The Mechanical Engineer and Prevention of Accidents which was followed by a general discussion by the members.

UNIVERSITY OF WISCONSIN

At a meeting for the election of officers held on February 28 by the University of Wisconsin Student Branch the following were elected: Honorary Chairman, Prof. H. J. B. Thorkelson; President, F. B. Sheriff; Vice-President, George Dorr; Secretary, L. F. Garlock, Assistant Secretary, J. E. Fuller and Treasurer, R. L. Larsen.

YALE UNIVERSITY

At the meeting of the Yale University Student Branch held February 14, Frederick A. Waldron, Mem.Am.Soc.M.E., gave a general discussion of the advantages of modern shop methods, showing how the separation of the departments under individual foremen tends to increase the efficiency of plants formerly operated under the superintendent system. Plans were discussed for taking trips of inspection to well known plants in near-by towns. At the meeting held on March 8, W. S. Murray, chief engineer of the electrification of the New York, New Haven and Hartford Railroad, gave an illustrated talk explaining the construction and operative details of that system, after which the usual informal discussion among the members of the branch was held.

MEETING OF THE COUNCIL

A meeting of the Council was held on March 10, in the rooms of the Society. There were present: E. D. Meier, President, presiding, Stanley G. Flagg, Jr., H. L. Gantt, James Hartness, Alex. C. Humphreys, F. R. Hutton, E. B. Katte, I. E. Moultrop, Jesse M. Smith, H. H. Vaughan, R. M. Dixon, and the Secretary. Regrets were received from Geo. M. Brill, D. F. Crawford, E. M. Herr, W. F. M. Goss and Wm. H. Wiley.

Voted: To rescind R 4.

The Secretary read the report of the Membership Committee with names of approved candidates under the grades suggested.

Voted: That the records of such candidates together with additional names to be approved by the Executive Committee be posted in the Professional Record Sheet to be issued in March and sent to the voting membership in advance of the regular ballot.

Voted: To accept the resignation of Gregory C. Kelley from membership.

The Secretary reported the deaths of the following members: W. H. Corbett, S. E. Freeman, Wm. B. Mason.

Voted: That the resignation of J. Sellers Bancroft as Manager be accepted with regret.

Voted: That the Secretary cast one ballot electing H. G. Stott, as the unanimous choice of the Council to fill the unexpired term of Mr. Bancroft under the provision of C 29.

Professor Hutton presented the report of the Committee on Constitution and By-Laws.

Voted: On recommendation of the Committee on Student Branches, to approve the formation of a Student Branch at Washington University, St. Louis, Mo.

The minutes of the Council meetings of January 10 and February 14 were approved.

The meeting adjourned.

NECROLOGY

CHARLES WALLACE HUNT, PAST-PRESIDENT AM.SOC.M.E.

The death of Charles Wallace Hunt. Past-President of the Society, on March 27, 1911, is announced. An account of his life will appear in an early issue of The Journal.

WILLIAM B. MASON

William B. Mason was born at Durham, Me., December 22, 1852, and died at his home, Dorchester, Mass., February 4, 1911. He received a common school education and first went to work in a machine shop at Biddeford, Me. He later came to Boston and was employed at the Hinckley Locomotive Works and as engineer on various harbor steamers. Mr. Mason then joined the navy as machinist and was assigned to the U. S. S. Omaha. He served for two years on the Pacific Station off the west coast of South America. Returning to Boston he accepted a position with Cressey and Noyes and while there invented the Mason steam pump speed governor, which is today the standard method of control of direct-acting steam pumps. In 1882 the Mason Regulator Company was organized to manufacture the instrument. When this enterprise was well under way Mr. Mason turned his attention to the design of a pump pressure regulator for controlling the discharge pressure on steam driven pumps. He later adapted the same principle to a reducing valve of which many thousands have been made for use under a great variety of conditions. When steam heating was adopted for use on railroad cars the Mason reducing valve was found to be the only one that could be satisfactorily employed and the leading railroad systems of this country, Great Britain and continental Europe have made it their standard. The business was broadened by numerous other devices for controlling steam, water and air at all pressures. When the manufacture of steam automobiles was first attempted by the Stanley Motor Carriage Company, Mr. Mason designed their engine and afterwards manufactured several thousand for the various steam carriage manufacturers.

He was a member of the New England Railroad club.

JOHN O. NORBOM

John O. Norbom was born at Fredrikssbad, Norway, September 12, 1865. He was graduated from the Horton Technical School, Horton navy yard, Norway, in 1883 with the degree of M.E., and for two years worked as draftsman at Fredrikssbad Mekaniske Verksted, Norway. Mr. Norbom then came to this country and was employed at the Risdon Iron Works, San Francisco, Cal., as engineer in the mining department. In 1895 he accepted a similar position with the J. Hendy Iron Works and two years later became manager of the mining department of the British Columbia Iron Works, Vancouver, B. C. He next held the position of mechanical engineer in the mining department of the Union Iron Works, San Francisco. From 1901 to 1903 he was consulting engineer at the East Rand Proprietary Mines, Johannesburg, Transvaal. After the Boer War he returned to his native country, where he examined mines for a London mining syndicate. In 1908 he resumed his work in California as mining engineer.

Mr. Norbom met his death by an accidental explosion on a ferry-boat on the Bay of San Francisco, January 13, 1911. He was a member of the American Institute of Mining Engineers and the Polytechnical Society of Norway.

THE EDISON ROLL CRUSHERS

By W. H. Mason

ABSTRACT OF PAPER

The causes leading to the design of the Edison crushing rolls are outlined and a comparison is made of the energy of coal as compared with that of dynamite in breaking up stone in the quarry. A description is given of the method of quarrying now employed in conjunction with Edison roll crushers. These rolls store up kinetic energy for use in crushing and sledging large stones and a comparison is made in this connection of rolls of various sizes. The power required for crushing by this method is shown by tachometer records, from which speed, energy and horsepower curves are plotted. Records are given covering a period of two years of the time lost and the cost of repairs on the crushing plant at the Edison Portland Cement Company. Comparisons are made between the theoretical capacity of these rolls and the actual capacity as shown by tests. Both of these are enormously greater than for the gyratory crushers and in addition, the larger size of the stones which can be handled by the rolls greatly simplifies and cheapens the quarrying operation. A description is given of the crushing plant of the Tomkins Cove Stone Company which has a capacity of 1000 tons an hour.

O.K.

THE EDISON ROLL CRUSHERS

By W. H. Mason, Stewartsville, N. J.
Member of the Society

The rapid growth of concrete construction in this country is causing unusual interest in the manufacture of cement, most of which is made from broken stone which also constitutes about two-thirds of the bulk of ordinary concrete. This paper discusses the Edison method of quarrying and crushing stone, both for the manufacture of cement and for concrete, railroad ballast, macadam, etc.

2 Some years ago, Thomas A. Edison experimented with the concentration of a very lean magnetic iron ore at Edison, N. J., employing the usual plant for crushing stone, which consisted of several jaw crushers. The stone in the quarry was drilled with a close spacing of drilled holes, and after being blasted was broken up by hand sledging into pieces of approximately 100 lb. in size. This caused a large expenditure for drilling, dynamite, hand sledging and hand loading. Mr. Edison soon realized that in concentrating this lean iron ore commercially it was necessary to reduce the cost of quarrying and crushing to a much lower point than had been realized heretofore in operations of a similar character, for in order to produce one ton of concentrates it was necessary to quarry, crush and treat about four tons of the lean ore.

3 In approaching this problem, Mr. Edison reasoned "the total heat or energy in 1 lb. of pea coal is approximately 12,500 heat units, but only about 15 per cent of this, or 1875 B.t.u., is available in mechanical energy through the medium of boilers and steam engines, while the available B.t.u. in 1 lb. of nitro-glycerine is approximately 3650. Therefore, in 50 per cent dynamite there is available 1825 B.t.u. per lb. or the same mechanical power that can be derived from 1 lb. of coal. But 1 ton of pea coal is worth approximately $2.50, while 1 ton of dynamite is worth about $250, making

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

the commercial advantage of the coal over the dynamite approximately 100 to 1."

4 Realizing also that a large part of the dynamite used in ordinary quarrying operations was expended not so much in breaking out the stone from the ledges in the quarry, but in reducing this stone to such sizes as could be handled in the crushers, he set out to design a crusher capable of taking much larger stone. He first constructed a pair of rolls 5 ft. long and 6 ft. in diameter having small protuberances on the surfaces, as shown in Fig. 1. This would take and crush larger pieces than the jaw crushers then in use, but if a stone were fed to the rolls greater than the angle of grip of the rolls, it would ride on top and rapidly wear down the knobs on the plates or tear the plates from the surface of the rolls.

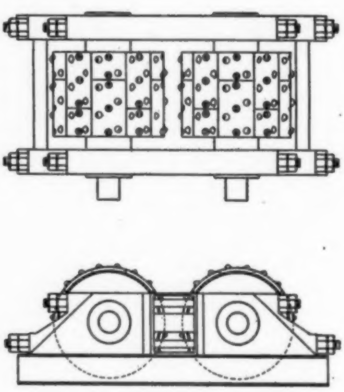


Fig. 1 Original Rolls Patented in 1895

5 Mr. Edison then invented the slugger, consisting of two rows of high knobs on one roll set diametrically opposite (Fig. 2). These knobs were put on with the idea of mechanically slugging the larger stones to such a size as to come within the angle of grip of the rolls. He had found that the rolls would frequently stop on receipt of a large charge of stone, not having sufficient power to crush the rock. To remedy this he ran the rolls at a much higher speed than when they were first erected, storing up sufficient kinetic energy to perform the actual crushing operation. This increase of speed accomplished two purposes: it increased the kinetic energy and delivered a much harder blow from the slugging knobs.

6 When the rolls receive a stone larger than they can grip, it tends to ride on top of the rolls, but the slugger prevents this, since it delivers 440 blows per minute and the stone must rise two or more inches in approximately $\frac{1}{24}$ of a second or be shattered.

7 The rolls were designed primarily to reduce the expense of quarrying, which is usually much larger than the crushing costs, whatever type of crusher is used. In order to do this, it was necessary to set the drilled holes far apart and to blow out the stone or ore in large pieces, thus making a great saving in both drilling and blasting. Mr. Edison also had especially constructed two steam shovels, much heavier than any previously built and special cars to load, trans-

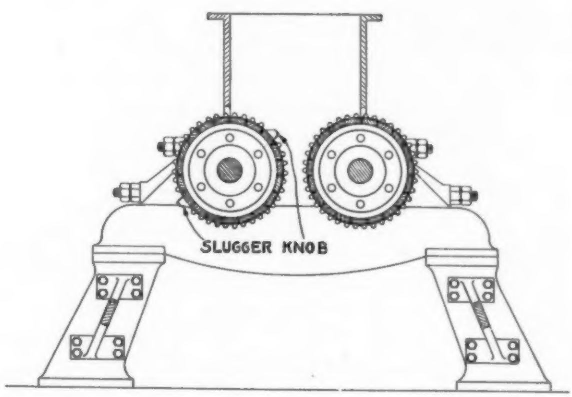


Fig. 2 Original Rolls with Sluggers added

port and dump these large pieces of stone into the rolls. With this combination it was possible to reduce the cost of quarrying and crushing to about one-fourth of what it had been when using the jaw crushers. About the time these improvements in quarrying and crushing were made, the development of the Mesaba iron ore deposits caused such a reduction in the price of iron ore that the Edison plant, with its extremely low-grade ore was unable to compete.

8 Having developed these crushing rolls and much other machinery for handling and milling ore or stone, Mr. Edison subsequently projected the Edison Portland Cement Company and there installed the set of 5 ft. by 5 ft. rolls shown in Figs. 3 and 4. These views show the

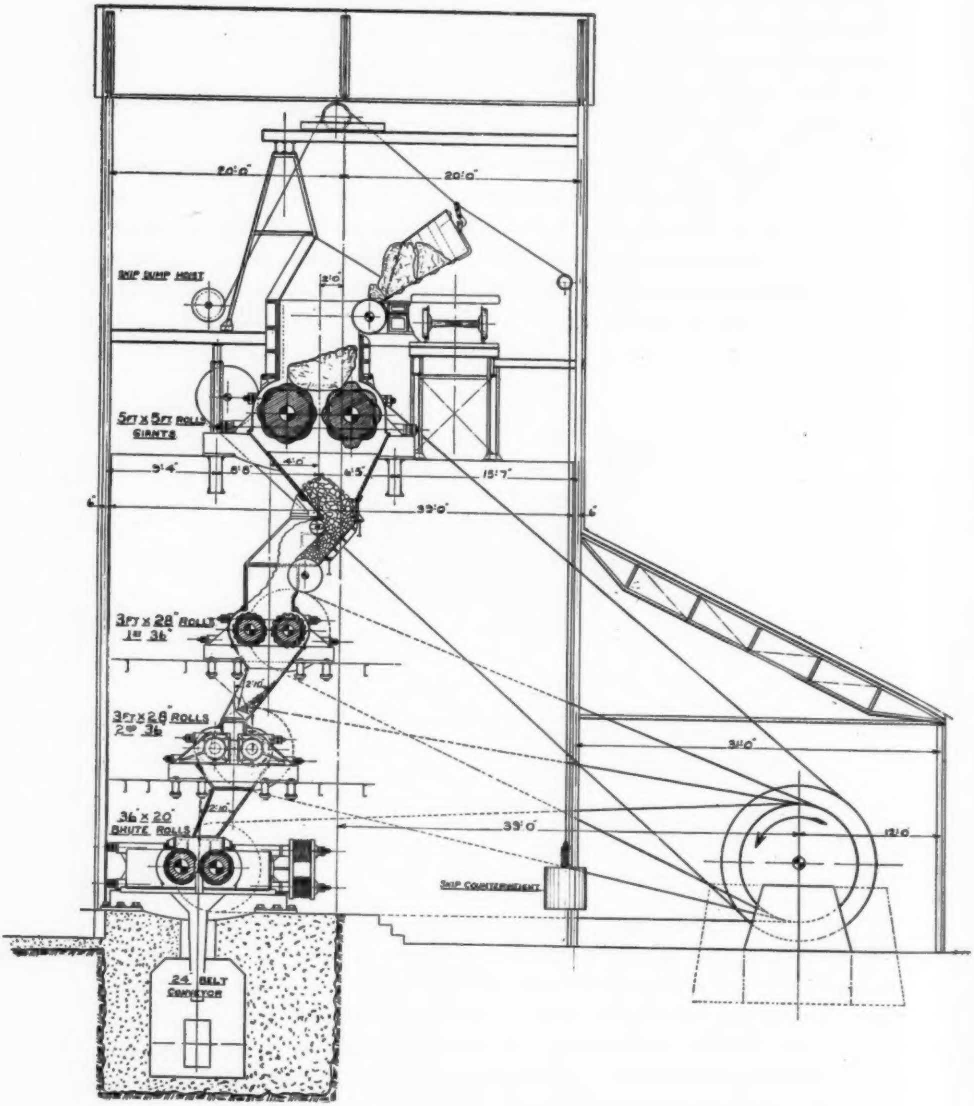


FIG. 3 SECTIONAL VIEW OF THE CRUSHING PLANT OF THE EDISON PORTLAND CEMENT COMPANY

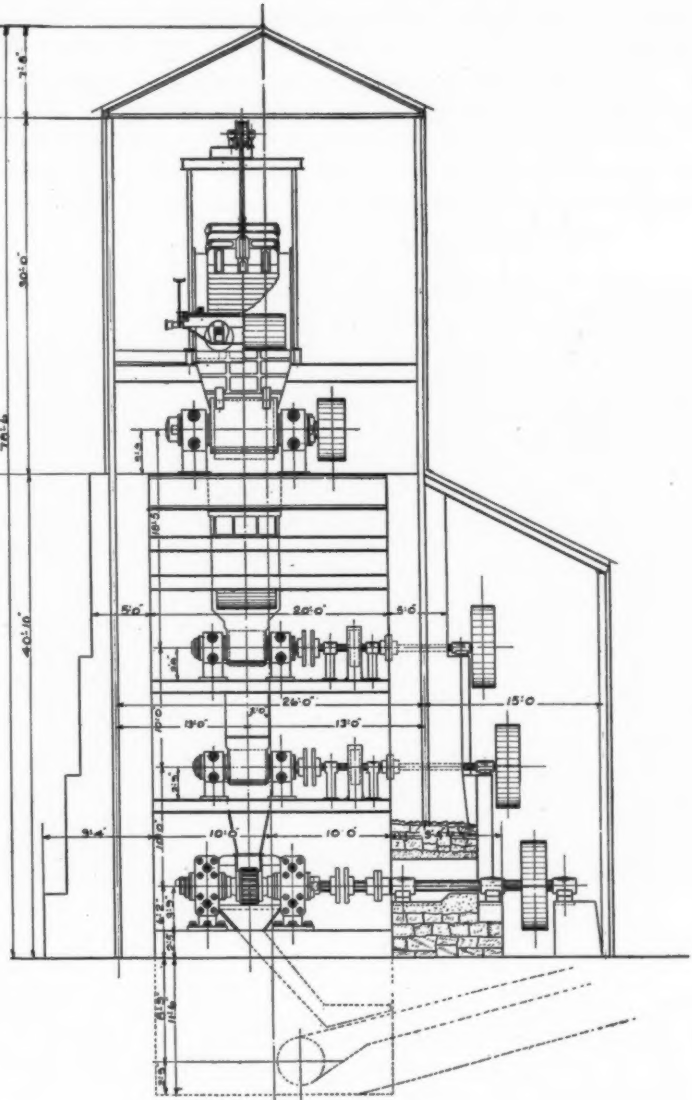


FIG. 4 END ELEVATION OF THE CRUSHING PLANT OF THE EDISON PORTLAND CEMENT COMPANY

general arrangement of the crusher house, containing 4 sets of rolls, which reduce the stone successively from pieces weighing 8 tc 10 tons to ½-in. chips. This crushing plant has been in operation for 8 years.

9 Before Mr. Edison constructed his giant rolls, the largest rolls n use were those known as the Cornish rolls, which were geared

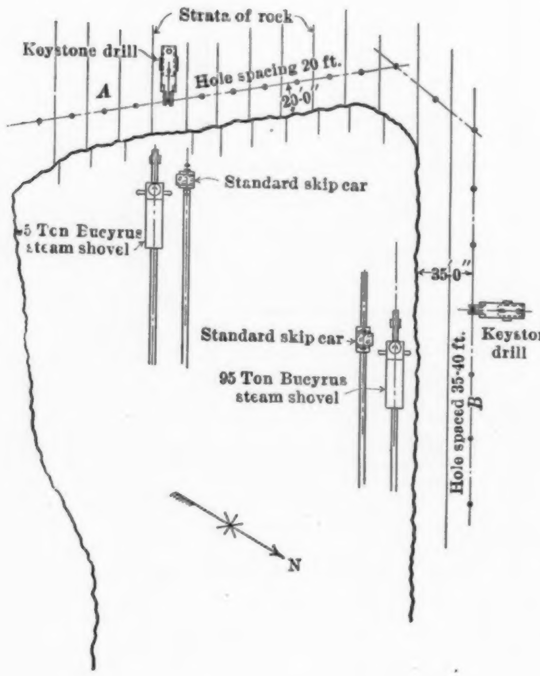


Fig. 5 Diagram of Cement Stone Quarry

together. The kinetic energy of a pair of these rolls, 16 in. in face, 30 in. in diameter and 100 r.p.m., is 8100 ft-lb. The kinetic energy of a pair of 5 ft. by 5 ft. Edison, 220 r.p.m. rolls is 2,280,000 ft-lb. The kinetic energy of a pair of Edison rolls, 6 ft. in. diameter 7 ft. long at 175 r.p.m., is 4,217,000 ft-lb. The largest gyratory crusher that the writer knows of has a 42-in. opening; that is, it will take a stone something less than a 42-in. cube, while the Edison 6 ft. by 7 ft. giant rolls will take a stone about 7 ft. cube. The 42-in. cubic stone weighs

approximately $3\frac{1}{2}$ tons, while a 7-ft. cube weighs approximately 28 tons, which is probably larger than can be handled economically by the largest steam shovels now manufactured. It is an ordinary occurrence, however, to crush a stone weighing over 15 tons.

10 The cement stone quarry of the Edison cement plant is an open cut with the strata running vertically or approximately so. The stone rises from 60 ft. to 80 ft. above the floor of the quarry, with a 3-ft. or 4-ft. layer of clay on top, which is removed by a small revolv-

Fig. 6 Steam Shovel Loading Large Stones

ing steam shovel and loaded into carts. Holes are drilled with a churn drill from the top of the quarry to about 6 ft. below the floor. These holes are 6 in. in diameter and about 20 ft. apart and set back about 20 ft. from the face of the quarry, which is worked on two sides, at *A* and at *B*. On account of the stratification, indicated in Fig. 5, it has been found necessary to use more dynamite when working face *A* than when working face *B*. While working *B* the holes can be spaced at least twice as far apart when using the same amount of dynamite in each hole as in those on face *A*. When a hole is drilled

it is usually squibbed in the bottom by putting 30 to 50 lb. of dynamite in the bottom of the hole and exploding it. This enlarges the bottom of the hole, making room for more powder at this point. Then the holes are loaded with 50 per cent dynamite, which fills up the portion which has been squibbed and runs up to about the level of the quarry floor. From this point to within 30 ft. from the top of the quarry the hole is loaded with 30 per cent dynamite. The remainder is tamped only, no powder being needed, since the explosion will shear off the top 30 ft. From 400 to 800 lb. of dynamite is put into each hole, and is then detonated by connecting the electric exploders to a 500-volt circuit from the power plant. The usual blast is from 6 to 14 holes. In some blasts we have broken down 60,000 tons of stone at one time.

TABLE 1 SIZES OF ROCK GRIPPED AND PASSED BY 6 FT. BY 7 FT. ROLLS FOR DIFFERENT SPACING OF ROLLS

Center to Center of Rolls		Bottom to Bottom of Corrugations	Size of Maximum Gripped	Maximum Cube Gripped	Maximum Cube Gripped	Maximum Stone Gripped at 165 Lb. per Cu. Ft.	Ratio of Cubes Gripped	Maximum Cube through Rolls	Maximum Cube through Rolls	Maximum Stone through Rolls at 165 Lb. per Cu. Ft.	Crushing Ratio
Ft.	In.	In.	In.	Cu. In.	Cu. Ft.	Tons		Cu. In.	Cu. Ft.	Tons	
6	2	6	6	13824	8.00	0.66	1.00	75	0.043	0.0035	38.0
6	5	9	27	19682	11.40	0.94	1.42	262	0.15	0.012	16.3
6	8	12	30	27000	17.80	1.46	1.95	614	0.36	0.030	9.2
6	11	15	33	35937	20.80	1.72	2.60	1331	0.77	0.064	5.6
7	2	18	36	46656	27.00	2.22	3.35	2744	1.58	0.130	3.5
7	5	21	39	59319	34.20	2.82	4.28	4913	2.85	0.235	2.5
7	8	24	42	74088	42.75	3.53	5.35	8000	4.63	0.383	1.9
7	11	27	45	91125	52.50	4.33	6.60	12167	7.00	0.580	1.6
8	2	30	48	110592	64.00	5.28	8.00	17576	10.15	0.840	1.3
8	5	33	51	132651	76.50	6.31	9.60	24389	14.00	1.150	1.15
8	8	36	54	157464	91.00	7.50	11.30	32768	19.00	1.560	1.0

11 Ninety-five-ton steam shovels are used to load this stone into special steel skips for transportation to the crushing plant (Fig. 6.) In loading stones of this kind, it is necessary to handle them on the teeth of the steam shovel dipper and to roll them off into the skip. Steam shovel engineers become very adept in doing this, frequently loading a 5 or 8-ton stone in 20 seconds. The train of stone is then delivered to the foot of the incline at the crusher and is pulled up, three cars at a time, by an electric hoist. The skip is loose on the car and is dumped by another electric hoist, as shown in Fig. 3. The entire contents of the car slides into the hopper over the giant rolls.

Two distinct actions take place here: first, the sledging action due to the rapid blows (440 per minute) of the slugging knobs in striking the pieces of stone too large to be caught by the angle of grip of the rolls; second, the rolling action as the pieces are sledged off and caught between the rolls. It requires ordinarily from 5 to 20 seconds to reduce to 6-in. sizes a stone weighing 6 or 8 tons.

12 The delivery of energy is so great in crushing stones of such sizes in so short a time that the rolls at once slow down in speed. The writer has made a number of tachometer tests (Figs. 7 and 8) showing the action of these rolls while crushing a stone. To make these tests, two special Shaeffer and Budenberg recording tachometers constructed with their dials geared together, so they revolved in unison, were used. The recording arms of the tachometers were connected

TABLE 2 MINUTES LOST ON ROLL CRUSHER

	Giant	1st 36 in.	2d 36 in.	3d 36 in.
Belt	2585	72	203	426
Choked	....	383	532	802
Large stone caught in hopper	955	....	....	....
Gears	....	1872	300	....
Starting	44	....	....	....
Bearings	168	282	....	20
Bolts	....	95	....	317
Plates	609	91	....	260
Shafts	337	....	238	....
Chain wobble	....	417	634	....
Sheared	....	1361	150	518
Miscellaneous	311	187	....	....
Total minutes lost	5099	4760	2057	2343
Total hours lost	85	79	34	39
Per cent ran	98¼	98¼	99½	99¼

one to each roll-shaft and the dials were revolved while the rolls were crushing the rock. By this means the speed of one roll with relation to the other could be determined at any instant. The tachometer chart (Fig. 7) shows that the slugger roll dropped in speed from 222 r.p.m. to 135 r.p.m. while crushing an 8-ton stone, and the regular roll (Fig. 8) dropped from 220 r.p.m. to 150 r.p.m., when they slowly regained speed until they reached normal.

13 While the second rock, almost as large as the first, was being crushed, the drop in speed was very much less. This may have been due to the fact that the stone was already partly shattered by dyna-

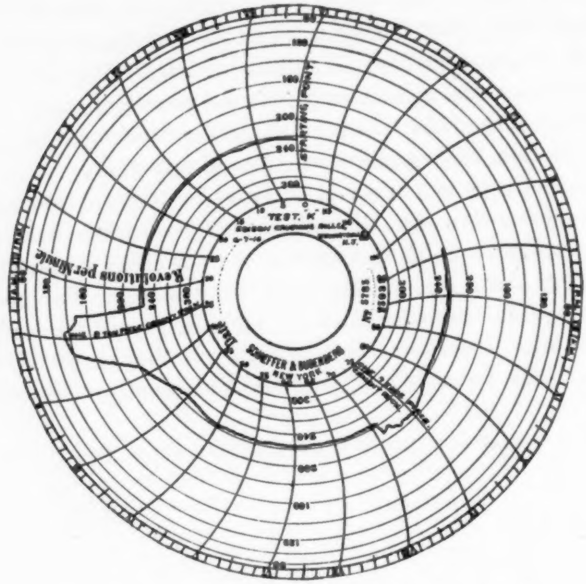


FIG. 7 TACHOMETER CHART FOR SLUGGER ROLL

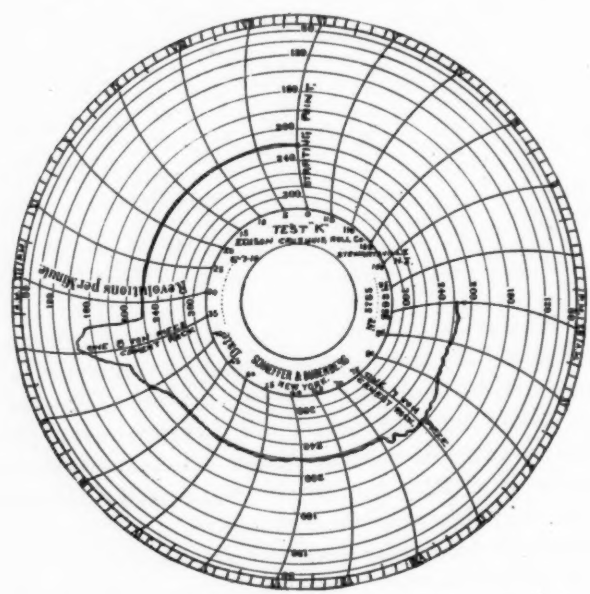


FIG 8 TACHOMETER CHART FOR REGULAR ROLL

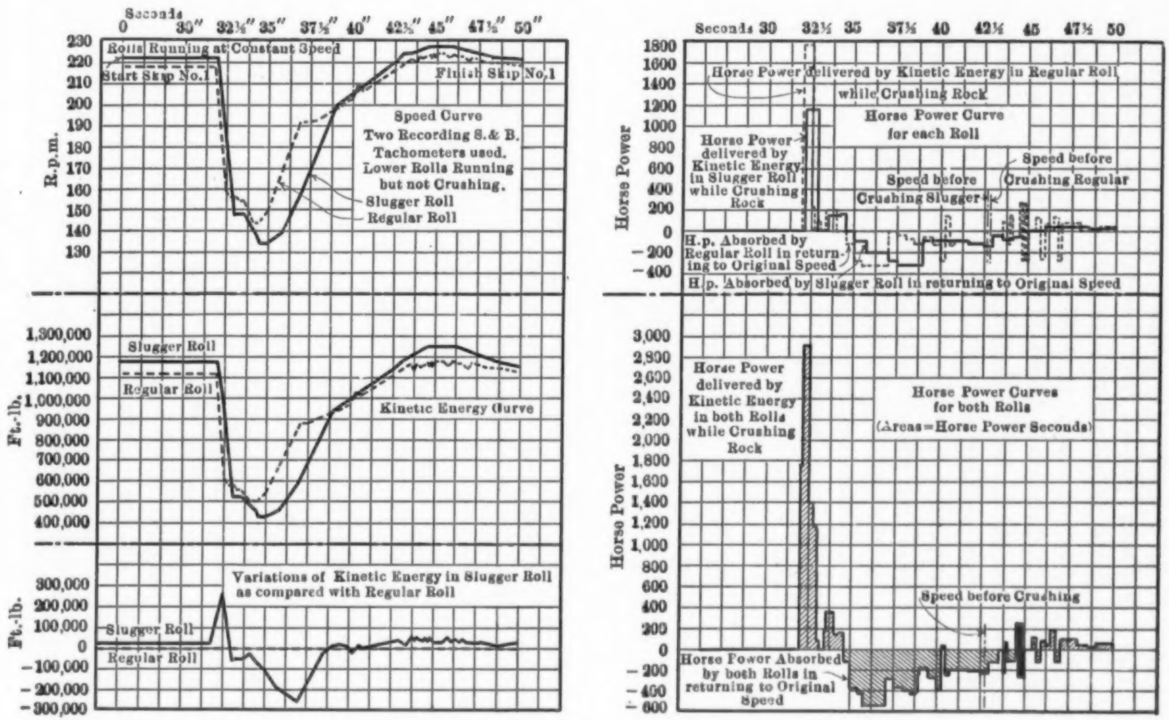


FIG. 9 CURVES PLOTTED FROM TACHOMETER CHARTS

mite, or to the manner in which it struck the roll. In the latter case the slugger roll ran constantly at a higher speed than the regular roll.

14 Fig. 9 is a chart plotted from the dial records on the first stone crushed, showing the reduction in speed of the two rolls at any instant. From this chart was plotted the kinetic energy curve for each roll, the weight of each being about 25 tons. The variation in kinetic energy is also shown for the slugger roll as compared with the regular roll during this crushing operation. From these curves were plotted the horsepower curve, showing the horsepower delivered by the kinetic energy of each roll while crushing this stone, and also the horsepower absorbed by the rolls in returning to the original speed. In the

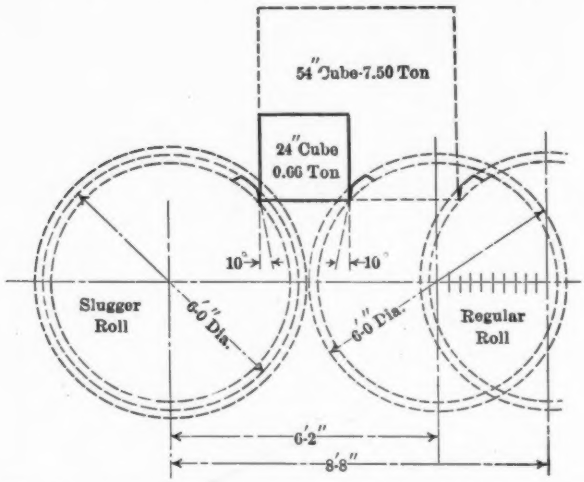


Fig. 10 Diagram of Crushing Rolls Showing Angle of Grip

last diagram on the sheet, by combining the above curves, the horsepower delivered by the kinetic energy of both rolls while crushing rock is shown, also that absorbed by both rolls while returning to their original speed. This shows that for approximately half a second the two rolls delivered 2900 h.p. in kinetic energy, and the engine supplied about 600 h.p. additional, making a total of 3500 h.p. to crush the stone.

15 It can readily be seen how necessary it is to use the kinetic energy of the rolls when crushing rock, as the rated horsepower of the engine which drives these rolls and the three sets of smaller rolls is only 500 h.p. It also shows that practically all the stone was crushed within 3 seconds, while it required about 10 seconds for the rolls to regain their original speed.

16 This reduction in the speed of the rolls occurs through the slipping of the drive belt over the pulleys. The engine slows down somewhat, but only a small amount compared to the slippage. As this slippage occurs only for a short time it causes no serious trouble.

17 The slugger roll does the most work in crushing the stone and should show uniformly a greater reduction in speed than the regular roll. This, however, is not the case, since the action of the stone in passing between the rolls tends to gear the rolls together or to absorb energy from the faster roll and to deliver it to the slower roll.

18 The angle of grip of the rolls is not a definite angle and varies with the fracture of the stone and with the diameter and spacing of the rolls. Fig. 10 and Table 1 show these variations quite clearly.

19 The Edison Portland Cement Company has kept an accurate Time Lost account with each piece of machinery. An accurate statement of the total number of minutes lost on each roll and the causes of such stoppage for the years 1909 and 1910 are given in Table 2. The total loss of time is 237 hours, out of a possible running time of 4814 hours. The total delays due to the 4 rolls, therefore, was 4.9 per cent of the possible running time, and the average tons crushed per operating hour was 224.

20 The actual cost of all material bought or manufactured by our shops for repairs on the rolls is available, but the actual labor of making the repairs cannot be accurately determined, since it is included in the item of repairs to the crusher, car hoist, dryers, conveyors, etc. The charges for material are itemized as follows:

Roll plates	$4454.90
Bearings	92.04
Gears, shafts, etc.	732.78
Plate and coupling bolts	240.88
Hopper plates	242.88
Belts	2192.19
Miscellaneous	762.72
	$8718.39

21 During this time (two years) the plant reduced 1,024,409 tons of stone from 10-ton pieces, so that all would pass a $\frac{3}{4}$-in. screen. This makes a plate cost per ton of $0.0043; belt cost per ton of $0.0021; general repairs per ton of $0.0021 and total repairs per ton crushed of $0.0085.

22 All of these rolls are driven by a prime mover inadequate to start them from a state of rest, and it is necessary to use levers or some similar device in starting.

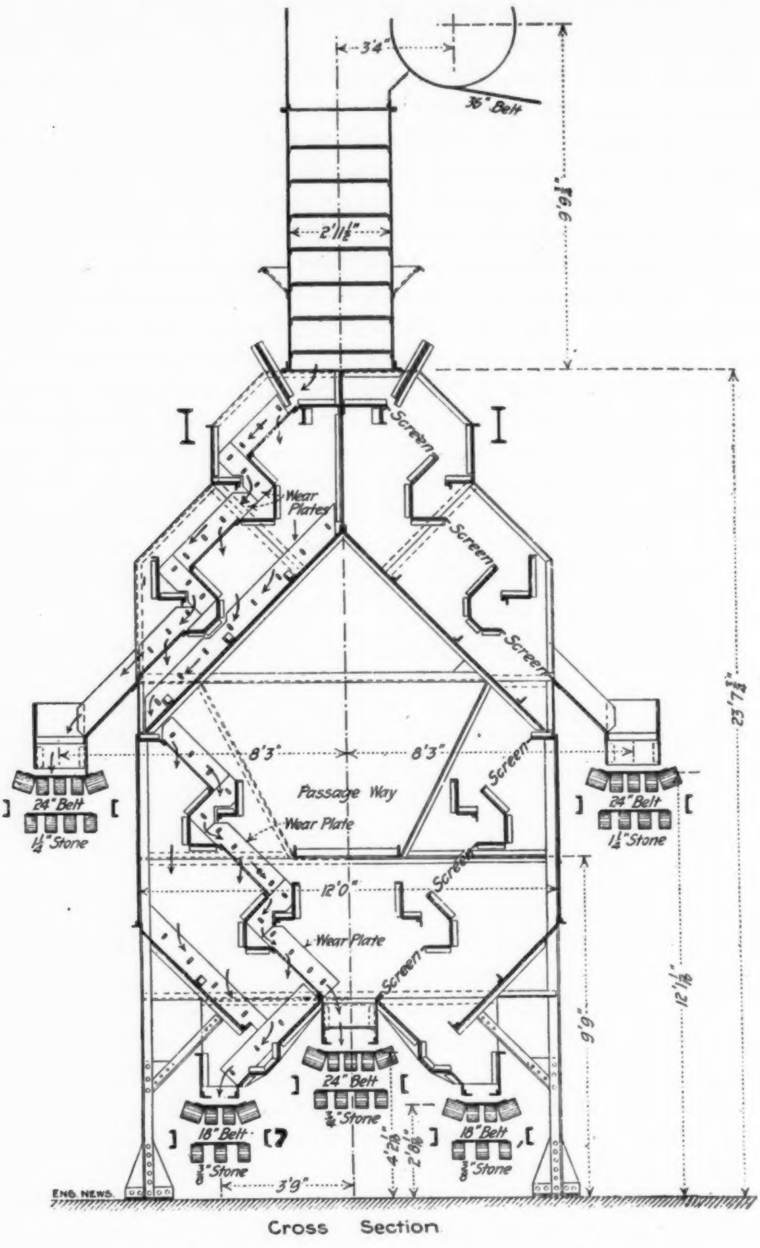


FIG. 11 SECTIONAL VIEW OF EDISON SIZING SCREEN

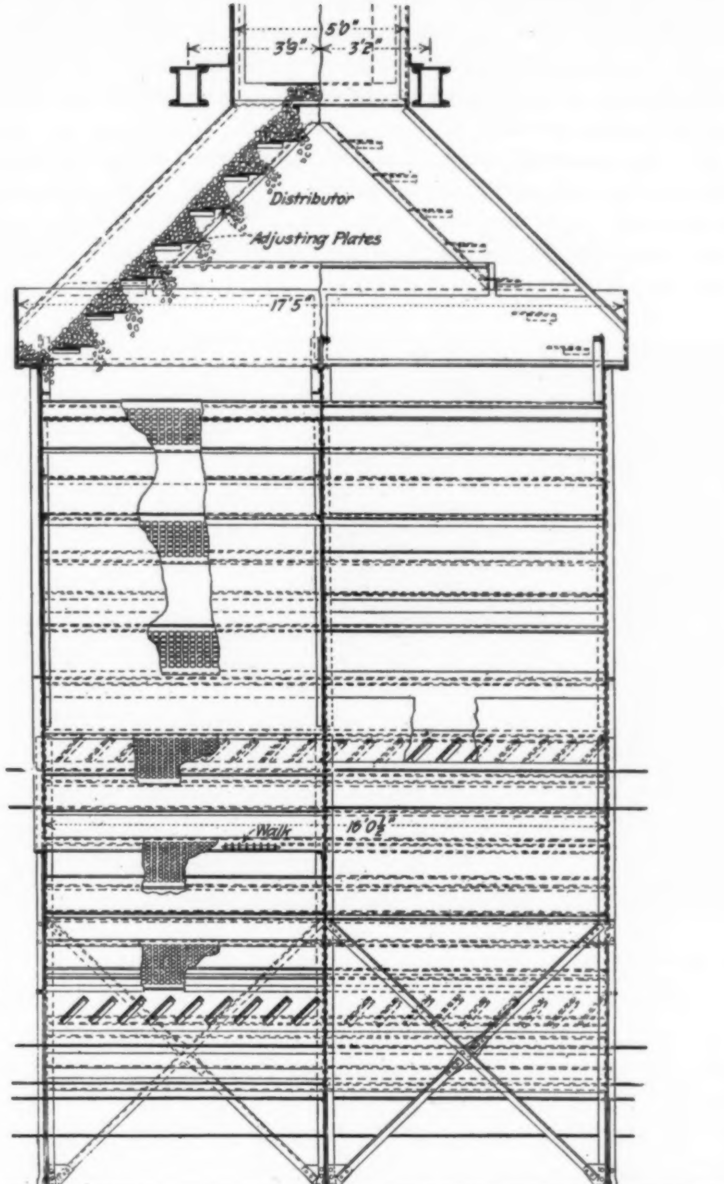


FIG. 12 END ELEVATION OF EDISON SIZING SCREEN

23 The strains set up when a 15-ton stone drops 10 ft. or more to the rolls are enormous, as are also the crushing strains, but they are largely taken up internally because the rolls act as an anvil. Only a comparatively small part of the shock is transmitted to the bearings or driving power.

24 The wearing surface of all the rolls is made of chilled cast-iron plates. On the giant rolls the chill is about 2 in. deep, while on the smaller rolls it is from ¾ in. to 1 in. deep. We have found that chilled iron, when properly made, wears much longer than manganese steel, and of course is much cheaper.

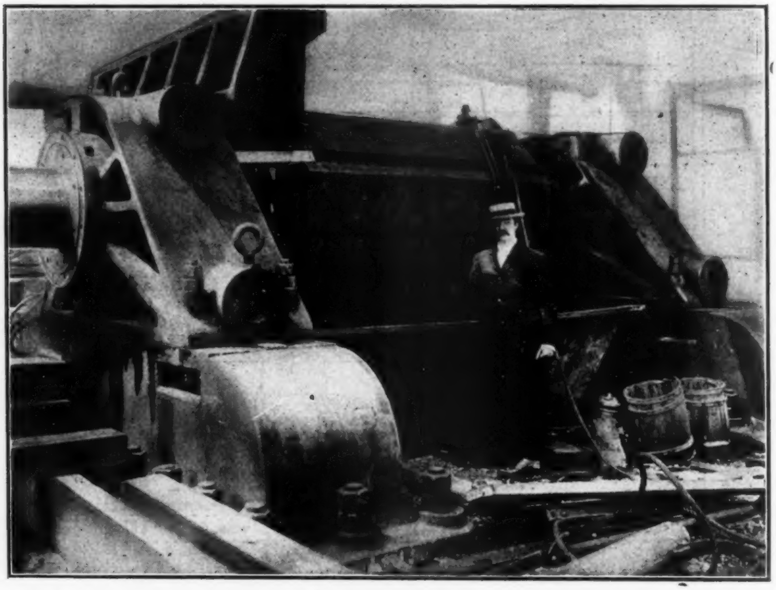


FIG. 13 GIANT ROLLS DURING ERECTION AT THE PLANT OF THE U. S. CRUSHED STONE COMPANY, CHICAGO

25 The capacity of the giant rolls is almost unlimited. In a recent test made on a pair of Edison rolls 6 ft. in diameter and 7 ft. long, 35 tons of stone were crushed in 32 seconds or at the rate of 4000 tons per hr. This was done at one of the quarries of the Kelly Island Lime and Transport Co. on a dolomite "run of quarry" loaded by steam shovels, the pieces being 4 to 5 tons or less. Side-dump cars were used on this test and they were arranged to dump automatically into the hopper over the rolls as the train was pulled by. It is needless to say that

at the end of the test the pan conveyor under the rolls was disabled and the rolls were running at a considerable reduction in speed.

26 The above figures may seem startling, but the theoretical capacity of the rolls is much greater when calculated on the same basis as that on which the capacity of smaller rolls is figured, and which the writer has frequently proved by actual tests to be correct.

27 The rolls are 6 ft. in diameter and 7 ft. long, are run at 185 r.p.m., and the average opening between the rolls is 9 in. This gives a surface speed to the rolls of 3487 ft. per min. or $\frac{3487 \times 7}{12} =$ 18,306 cu. ft. passed per minute. Assuming 20 cu. ft. per ton, this

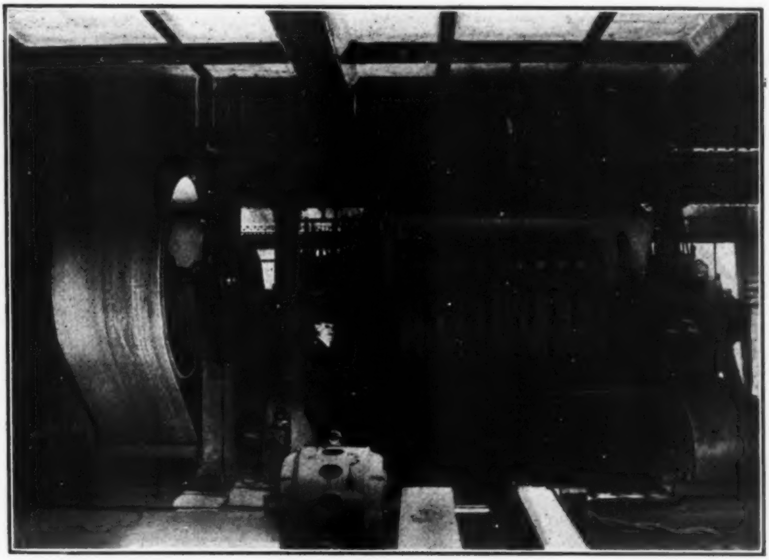


FIG. 14 GIANT ROLLS AT TOMKINS COVE—6 FT. BY 7 FT.

would be equivalent to 915 tons per min., or about 55,000 tons per hr.

28 The average horsepower required to drive these rolls while crushing 3000 or 4000 tons per day is quite small, ranging between 100 and 150 h.p., but the momentary peak loads are very much greater. One of the companies operating a pair of these rolls 6 ft. by 7 ft., motor driven, buy their power with certain peak load specifications. In order to reduce the peaks they have set a circuit breaker to cut off the current at about the normal load of the motor. After the stone is

crushed the current is turned on the motor, and the roll again brought up to speed. It frequently happens that the current is cut off the motors by this method as many as 50 times a day.

29 Fig. 13 shows a set of 6 ft. by 7 ft. rolls being erected at the plant of the U.S. Crushed Stone Company, Chicago, Ill., and gives an idea of the heavy construction necessary to withstand the great shocks. This also shows the mandrels to which the plates are attached.

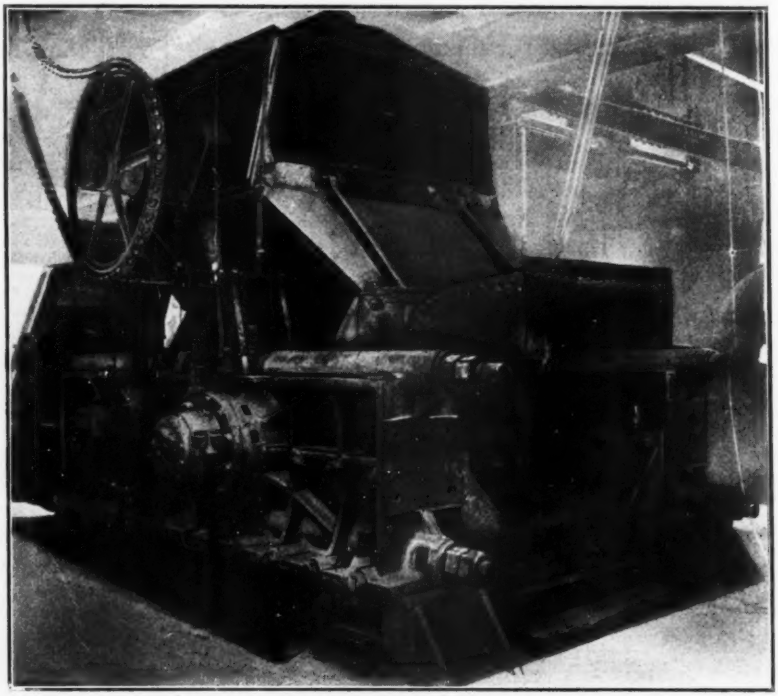


FIG. 15 INTERMEDIATE ROLLS AT TOMKINS COVE—4 FT BY 4 FT.

30 The crushing plant of the Tomkins Cove Stone Company, Tomkins Cove, N. Y.,[1] which was put in operation last fall, has, as far as the writer knows, the largest capacity of any plant in the world. Its extreme simplicity is one of the most striking features, and its design throughout is for a capacity of 1000 tons per hr. The stone,

[1] This plant was more fully described and illustrated in Engineering News, January 12, 1911.

after being loaded with steam shovels in the quarry, is dumped into a pair of 6 ft. by 7 ft. rolls, reducing it approximately to 8-in. sizes. Under these rolls there is a hopper having a capacity of about 30 tons. The stone is fed from this hopper by feed rolls to a set of 4 ft. by 4 ft. rolls, which run 250 r.p.m. This reduces the stone to about 3½-in. sizes when it goes directly to a set of 4 ft. by 3 ft. rolls and is reduced to about 1½ in. A large pan conveyor receives the stone and lifts it to an Edison stationary screen, which returns anything over 1½-in. sizes to the lower rolls for re-crushing. The product from this

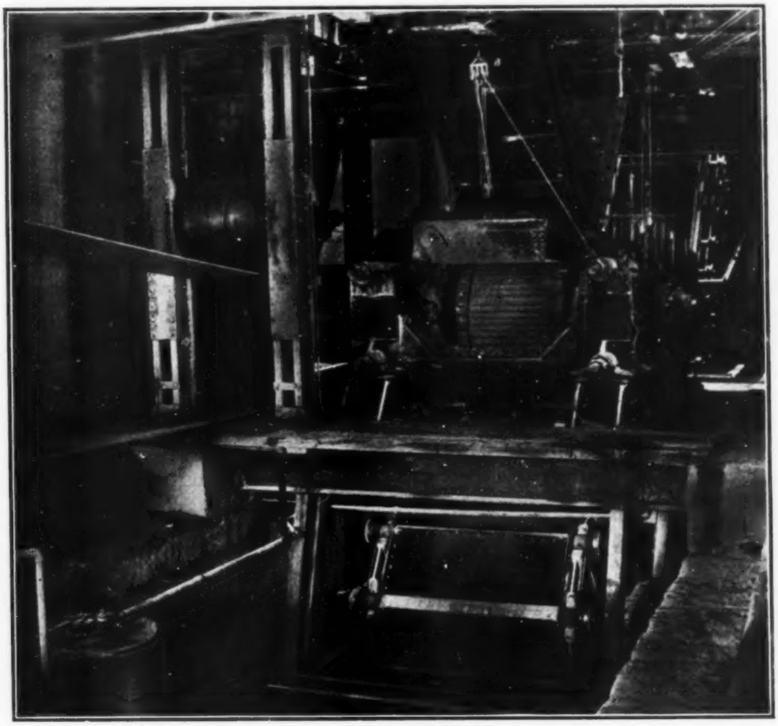


FIG. 16 FINAL ROLLS AT TOMKINS COVE—4 FT. BY 3 FT.

screen is carried by a 36-in. belt conveyor to the Edison sizing screens (Figs. 11 and 12). Here it is divided into three sizes, known commercially as 1¼-in. stone, ¾-in. stone and ⅜-in. stone. It is carried by belt conveyors to concrete bins having a total capacity of 20,000 tons, from which it can be withdrawn and delivered by belt conveyors directly to barges or railroad cars.

31 The size of stone may be varied as desired by changing the openings between the rolls or the size of the openings on the screen plates.

32 Figs. 14, 15, 16 show the giant, intermediate and final rolls at the Tomkins Cove plant.

SOME PROBLEMS OF THE CEMENT INDUSTRY

By Walter S. Landis

ABSTRACT OF PAPER

Progress and improvement in the cement industry has and will resolve itself into the development of the plant as against the process. The chief features of interest in this plant development is the question of size of first crushing unit, the fineness of grinding of the raw materials before entering the kiln, the gradual displacement of the wet process by the dry one, better utilization of the fuel in the clinkering of the raw material, the abandonment of the air separator. The older mills must be remodelled along the lines of more economical power distribution and labor requirements to successfully compete with the modern mills, now that profits in cement manufacture have dropped so low.

SOME PROBLEMS OF THE CEMENT INDUSTRY

Walter S. Landis,[1] South Bethlehem, Pa.

Non-Member

If one were to ask the average mechanical engineer for information concerning the cement industry he would most likely be told that this industry belongs to the field of the chemist. This idea is quite as erroneous, as it is prevalent among mechanical engineers. It may be true that in the early days of the industry the chemist occupied the most important position, but today the mechanical engineer is at the head of our great plants and the chemist has degenerated into a very subordinate official. There are reasons for this change, the most important one being that it is easier for the mechanical engineer to pick up the necessary chemical knowledge than it is for the chemist to acquire the requisite mechanical training. Again, the rigid requirements as laid down by the early chemists for the manufacture of a passable product are no longer recognized as true since we have learned so much more about the technology of cement. As a result we have been having the development of the plant as against the process, and the mechanical engineer, of course, plays the most important part in such plant development.

2 What we today understand as Portland cement is a certain compound of silica, alumina and lime in the proportions of SiO_2, 20 to 23 per cent; Al_2O_3, 8 to 10 per cent; and CaO, 62 to 65 per cent. It is not possible to obtain these ingredients in large quantities in a state of absolute purity and we frequently find alumina replaced by ferric oxide, up to 3 per cent, and lime by magnesia, up to 2 or 3 per cent, so that actual cements as found on the market diverge slightly from the above analyses without, however, suffering greatly in their physical properties. It must also be remembered that the well-known Portland cement is only one of a dozen chemical compounds which

[1]Associate Professor of Metallurgy, Lehigh University.

harden or set when mixed with water and that it has attained its great importance because of the ease and cheapness with which it can be manufactured and not because of any peculiar properties not possessed by certain other compounds.

3 Simply the mechanical mixing of silica, alumina and lime in the above proportions will not yield a compound possessing the properties of Portland cement. It is essential that these ingredients be in a manner combined, not exactly as a true chemical compound, but rather as a physico-chemical solution of one or more chemical compounds in each other. The mixture must be finely ground before it will exhibit the characteristic setting property. The best and practically the only way in which such a union can be attained is by a complete or partial fusion of the silica, alumina and lime mixture. Such a partial fusing is called sintering or clinkering.

4 All the laws of physical chemistry relating to the formation of slags and fused mixtures apply also to the formation of the clinker, a few of the more important facts being here mentioned. The melting point and the clinkering temperature are dependent on the purity of the mass clinkered, being lowered by the presence of such impurities as oxide of iron, magnesia, alkalis, etc. It is a well-recognized fact that the so-called white or stainless cements require a much higher temperature for clinkering than the dark colored and more impure mixtures. The temperature required for clinker formation depends on the intimacy of the contact of the various clinkering ingredients, the finer the individual materials are ground the lower the temperature required.

5 Since we know that such a thing does not exist as an overburned cement, a fusion of the properly proportioned ingredients would solve the question of a homogeneous product. But such a fusion has not proved advisable in practice and the cement manufacturer has had to content himself with a sintered or clinkered product, that is, one which has been raised in temperature to a sticky or viscous stage and not actually liquified. As such clinkered product is at no time a mobile liquid we cannot depend on liquid diffusion for the proper mixing of the silica, alumina and lime but must do such mixing purposely. To ensure the necessary contact between these ingredients so that they can unite chemically to a homogeneous whole when in the state of only incipient fusion, they must be most finely ground and most thoroughly mixed. Therefore the first stage in all cement processes, as at present practiced, is a preliminary grinding and mixing of the raw materials.

6 The first consideration in the grinding of a material is a study of the properties of the material to be ground. This in turn leads us to a description of the raw materials entering into the manufacture of Portland cement. Of first importance among these is cement rock, an argillaceous limestone, lying both in composition and in geological position between the true limestones and the slates. It is a natural mixture of carbonate of lime and clay, which on heating to the clinkering temperature loses its combined water and carbonic acid and unites together into a fritted mass of the desired composition and properties. It is shaly in nature, not very hard, and of varying degrees of toughness. In several favored parts of the country, as for instance one or two places in the Lehigh Valley region, this rock needs no further treatment other than quarrying, comparatively coarse crushing and burning to form a first-class clinker. Usually the ingredients are not present in the natural rock in exactly the desired proportions and the one lacking, generally lime, must be added. Sometimes in this region there will be two strata or benches in the same quarry so constituted that by mixing rock from the two in certain proportions, the silica, alumina and lime will be in the desired proportions in the clinkered product.

7 Where materials are found to be so near the desired composition as to require practically no mixing, the grinding is a simple proposition. Only such fineness would be required, if the rock were of uniform composition, as would insure the kiln producing a properly burned product when run at a predetermined capacity. This would really be a sizing rather than a grinding. On the other hand, if the rock is non-homogeneous or requires some mixing to make a properly constituted clinker, then finer and finer and finer grinding, proportionate to the degree of non-homogeneity or amount of mixing required, must be done to enable the mixture to attain the composition desired in the clinker. No hard and fast rule can be laid down for the required fineness of grinding. It must be suited to the individual case, remembering that sometimes the financial success of the plant depends on making a passable product with the coarsest allowable grinding. The kiln temperature, as well as the length of time the mass is subjected to this temperature, influences the required fineness of grinding. The finer the grinding the easier the clinkering and, therefore, the capacity and coal consumption of the kilns are directly proportional to the fineness of the ground mix fed in. It has been found in practice within the past few years to be more economical to grind very fine before burning, even though such a degree of fineness of the raw material would

not actually be required to make a satisfactory clinker. In other words, the coal used to drive the grinding machines to produce this extra fineness is less than that saved in the kiln, and at the same time the capacity of the kiln is greatly increased. It has also been said, though I cannot verify it from actual observation, that the finer the grinding of the raw material the easier the clinker is to grind afterwards. This might be explained by the fact that the lower temperature at which the finer mix clinkers leads to the formation of a softer clinker. In that case the power put into the preliminary grinding would at least be partially saved in the finishing department. A more thorough study of this question is one of our problems.

8 But it must not be understood that the manufacture of cement is confined to those favored localities in which cement rock is found. A mixture of clay and limestone can be prepared artificially of such composition that when the combined water in the clay and the carbonic acid of the limestone are driven off by heating, the residue will form clinker of the desired composition. Here we have materials of entirely different composition and nature to be mixed, and the grinding of each must be exceptionally fine in order that they may combine under ecomonical conditions of kiln running. It is recognized by cement men that the manufacture of a satisfactory cement from limestone and clay entails a different mill equipment from that in use in the Lehigh Valley region, where the raw material is a nearly perfect cement rock. Such raw materials, to be properly mixed, *must* be ground so that practically all will pass a 100 mesh screen and nearly all a 200 mesh.

9 Other raw materials available are marl mixed with limestone or clay, shale mixed with limestone, and even blast-furnace slag mixed with limestone. This latter material is at present receiving a great deal of attention from cement men. The iron blast-furnace slag is composed of silica, lime and alumina, and by the addition of limestone, clinker of the desired composition can be produced. It has the advantage of being a waste product which the furnaces are glad to get rid of and at the same time needs no quarrying or coarse grinding, since it is granulated in water when tapped from the blast furnace. All materials like clay and limestone require exceedingly fine grinding (all through 100 mesh, 50–70 per cent through 200 mesh) in order to insure proper combination in the kiln.

10 It is not possible to discuss in detail the many problems connected with fine grinding of the large quantities of rock and clay which the cement industry handles. In quarrying the rock the percussion drill, such as is used in the digging of ordinary drilled wells, is largely

used for making the blasting holes, a series of holes being drilled along the face of the quarry 15 to 20 ft. back. The author has seen single blasts bring down from 20,000 to 40,000 tons of rock. After blasting, the rock is loaded up into dump cars in many quarries by the use of a steam shovel. These cars are moved to the foot of the hoisting incline by gravity or mule power, and are pulled up by a donkey engine. Considerable engineering skill must be brought to bear on the economical handling of the quarried rock in the quarry itself. After arriving at the top of the quarry the car is run into the crushing house, where the stone is weighed and dumped into the first crushing unit.

11 American and European practices differ in the size of this first crusher, which is almost universally of the gyratory type. With us, hand labor is expensive and must be dispensed with wherever possible. We therefore build this unit as large as is required to take any single piece of rock which the steam shovel can load into the dump car. When such a carload is dumped into the crusher the driving motor of the crusher suffers a momentary peak-load as the rock goes through, which load then drops off to nothing until the next car arrives. These crushers sometimes take a piece of rock 30 to 36 in. in diameter, using at the peak 250 h.p. In Europe, the rock as quarried is broken much smaller, usually by hand sledging, thereby permitting the use of a number of smaller gyratories, and so distributing the load on the motor more uniformly throughout the day. In our country the first large coarse crushers are followed by smaller ones of the same type, and in the newer mills these are driven from the same power source as the larger ones.

12 The advisability of using the very largest types of crushers made is a much discussed point among cement men. When one considers that the very large pieces of rock quarried are the exception rather than the rule and that the crusher is rarely called upon to take one the size of its opening, it seems questionable to fit a mill with such a machine. A stick of dynamite laid on such a large piece will easily reduce it to a size readily handled by the smaller crushers (even in this case larger than the European crushers), and so eliminate the enormous peak loads and expensive machinery. Several large new mills have not provided themselves with the largest procurable type of crushers made, even though their output would warrant it. This question of crusher size is another of the problems of cement manufacture awaiting final solution.

13 The drying of the product of the gyratories is the next stage in cement manufacture. The fineness to which the material is to be ultimately ground makes it necessary to remove all hygroscopic moist-

ure, otherwise clogging of screens and cutting down of capacity of the fine grinding mills would result. The driers are cylindrical steel shells capable of being rotated on their axes and are set slightly inclined in order to insure progressive motion of the charge through them. The wet, coarsely crushed material is fed in at the upper end and hot gaseous products from a coal fire or natural gas flame pass in at the lower end and over the charge to be dried. They are frequently provided with buckets, formed of Z-bars riveted to their inner surface, to pick up the rock and carry it part way around and so drop it through the gases passing through the drier and at the same time advance it through the kiln. At times they are divided into compartments to insure closer contact between the heating gases and the rock, but this design is gradually dropping out of use. The great decrease in capacity of a compartment drier over the ordinary type more than offsets the greater heat transfer from the gases to the feed. It is only recently that attempts have been made to utilize the hot gases from the kilns to perform the drying of the mix. Several such installations have recently been made and are working with great success.

14 The drying of clay for fine grinding presents an unusual problem, because after being dried it must be used immediately, as it again takes up moisture from the atmosphere. This usually results in a double drying operation: first just before disintegration, after which it goes into storage, and a second drying after lying in storage and just before final grinding.

15 From the driers the rock passes to one of the various types of fine grinding mills, such as the ball and tube mills, or mechanical mills like the Griffin and Fuller. The excellent catalogues furnished by the manufacturers of this class of machinery make it unnecessary to describe them in detail here and reference is made to them in full confidence in the reliability of the data there found. The product leaves these mills so finely ground that more than half of it will usually pass a screen of 200 meshes to the linear inch. It has been universal practice to fit the mechanical mills with screens (no screens in the tube mills) of 30 to 40 mesh openings, through which the product of the mill has to pass before discharge. Such screens are placed so that the material discharged from the mill strikes them at an acute angle and the full size of the opening is never available to the discharged product. Recently air separators have been tried as a substitute for the expensive and troublesome screens. The success of this installation is doubtful, for the conditions under which air separators work most efficiently are not the conditions under which ground material should

be prepared for the cement industry. A word of explanation will make this clear.

16 The screens having been entirely removed from the mill or replaced by much coarser ones permit a continuous supply of partially ground material to pass to the air separator for sizing, say to 100 or 200 mesh as desired, the oversize being returned to the mills for further grinding. With proper operation of such an air separator very little of the material will be ground finer than the air separator is adjusted to sort out. Now it is a well-known fact that the finer the materials entering into cement manufacture are ground, the better the product made. Since air separation furnishes a very uniformly sized product, this desirable extra fine grinding is eliminated. The screens, on the other hand, offer difficulty to the passage of product out of the mill, keeping a large part of the charge under grinding influence for some time after it has reached screen size, reducing it finer and finer in size. Thus some of the product discharged from a mill having 30 to 40 mesh screens may be 500 or 1000 mesh in size, a condition not realized in highly developed air separation. It is, however, admitted that air separation leads to greater capacity of output of the grinding unit, though at the expense of quality.

17 So far nothing has been said of the mixing of the raw materials to insure proper composition of the finished cement. This mixing practice has varied greatly. Originally the several ingredients were ground separately, mixed with water until thin enough to flow readily, and streams of each run upon a drying floor. Their fluidity insured mixing. After drying for some time, the mass was rolled into balls or pressed into bricks, and stored until ready for charging into the clinkering furnaces. Today this practice is obsolete and in its place we have the two great systems under which modern mills operate. They are known as the wet and the dry processes, their chief differences being based on the operation of mixing. In the wet process the two ingredients are ground separately, mixed with water until thin enough to flow, pumping assisting in this conveying if necessary, and are charged in approximately the desired proportions into large agitating tanks for mixing. The final adjustment of the composition is made in these tanks. The wet mixture is then pumped from these tanks directly to the kilns.

18 In the dry system the properly weighed and proportioned materials are first separately crushed in the coarse crushers, and are fed together into the fine grinding mills, practice varying somewhat as to the exact mill into which the two materials first come into contact.

The operation of grinding performs all the mixing required. For the same material it is supposed that finer preliminary grinding is more necessary in the dry process than in the wet for the same quality of cement. It seems to the author useless to add 50 to 100 per cent of water to a mass of ground material and then to evaporate that water again, when the dry process is working so satisfactorily.

19 Considerable changes have been made in the arrangement of the preliminary or raw grinding side of the mills as the industry developed. It is expensive to handle material and to transmit power. In the older days of the central power plant and lineshaft drive, the mills were arranged solely with a view to economy of power transmission and much handling of the material between the various crushing and grinding units was the result. Today the individual motor drive is supreme, with the result that I have seen modern mills so laid out that there is scarcely any handling of material in the whole grinding department, the first elevation occurring into bins above the kilns. Gravity was used to feed from one unit to the next. Such an arrangement is not always the most advantageous when it comes to a breakdown; and the mill must be built on a hill-side, which means awkwardness in handling repair parts. The ideal mill would probably require at least three elevators in this department, and since the power required by such elevators would be hardly over two or three per cent of the total power installation of the plant, it is really not a serious item.

20 Another feature of mill design receiving attention is storage capacity. The rough handling of the machines causes them, rugged as they are, to be laid off for repairs. It is necessary, to insure running of the mill to provide ample storage capacity between the various classes of grinding machinery so that a stoppage of one part will not cause the shutdown of the entire mill. Several very recent mills have provided storage capacity as follows: a 4-day supply of gyratory discharge, a 12-hour supply of ball mill feed, a 12-hour supply of finishing mill feed and a 24-hour supply of kiln feed. It must be remembered that climatic conditions have a marked influence on the consideration of storage capacity.

21 The kilns originally used for burning the mix to clinker were fixed, vertical, bottle-shaped furnaces. The balls or bricks made by the old wet process previously described were fed in at the top and the burned product drawn out at the bottom. The product was so irregularly burned that hand sorting had to be employed to pick out the underburned product, this portion containing uncombined lime and not

being suitable for the manufacture of a sound cement. While the fuel consumption of such a kiln is much below that of the usual rotary kiln, the labor and attendance charges are very high and the apparatus has been obsolete in this country for many years. Even Germany, a country of cheap labor, is now replacing this type of kiln by our own rotary design.

22 The modern rotary kiln consists of a cylindrical steel shell lined with refractory material and supported on rollers in cradles, its axis being slightly inclined from the horizontal. A rotation on its bearings is secured through one of the many types of variable-speed transmission. Its upper end enters into what is called the chimney hood, a dust trap and chimney support combined, and its lower end into another movable hood adapted for the discharge of clinker and the entry of fuel nozzles for pulverized coal, gas or oil. Pulverized coal is the most widely used fuel in cement burning. In size these kilns vary from 60 ft long and 5 ft. in diameter up to 240 ft. long and 12 ft. in diameter. The output of a kiln is not easily determined, as it varies much with the nature of the product to be clinkered, the degree of fineness of the feed, the moisture to be evaporated, and whether the driving demands is for efficiency of operation or for capacity. Great capacity is not synonymous with high efficiency in a cement kiln. For example, a 60-ft. kiln in the Lehigh region will have a capacity of 200 bbl. of clinker per day and the 240-ft. kiln of approximately 2500 bbl. per day. The lining of the kiln, at least at the hot end, is either of bauxite or magnesite brick in the majority of installations, though a highly refractory fire-clay may be used. Either of the first two linings are of a much higher heat conductivity than the latter.

23 One of the features of kiln design needing the attention of the fuel engineer is the stack. One sees on the same sized kilns stacks of all heights and diameters and not all can be highly efficient and economical. Some steps should be taken to investigate this question and to formulate a standard design embodying economy and efficiency.

24 Some of the finely ground material fed into the kiln is picked up by the gases passing through the kiln and passes into the chimney. Provision must be made in its design for settling out as much as possible of this dust, and too often one sees a narrow chimney on a kiln carrying out clouds of finely ground material and scattering it for miles over the surrounding country. This material consists of the extreme fines so to be greatly desired in the product.

25 The physical and chemical reactions taking place in the raw material as it passes through the kiln, starting with its charging at the

higher or chimney end of the kiln are as follows: rise in temperature accompanied by evaporation of water, if present, such evaporation holding the temperature constant at about 100 deg. cent. in the wet processes; rise in temperature up to about 300 deg. cent. where any chemically combined water such as occurs in clay is driven off, the rise being less rapid during such dissociation; rise in temperature up to about 800 deg. cent., where the carbonic acid of the limestone is driven off, the rise in temperature being again sharply checked by the heat absorption occasioned by this decomposition; a rise in temperature up to that of clinkering, 1200 to 1400 deg. cent., depending on the various conditions existing in the chemical composition and physical properties of the mix as already discussed; rapid rise in temperature to a maximum, at times higher than the temperature of the flame in the kiln, due to the heat of combination of the ingredients in forming the clinker; rapid drop in temperature as the material is discharged from the kiln. It is not possible to define in feet and inches the length of each zone because of the variable character of the raw material in each cement producing district and of the great differences of kiln length. A specific case was discussed in the paper[1], read before the Society by Mr. Soper in November 1910.

26 If we consider for the time being the charge of a kiln in the Lehigh Valley region where cement rock and the dry process are used, the net heat required by the above chemical reactions would be furnished by the combustion of about 16 lb. of average long-flame bituminous coal per barrel of clinker formed. This amount would be increased where clay and the wet process are used because of the heat absorbed in evaporating water and decomposing the hydrated compounds. The average fuel consumption of coal-fired cement kilns throughout the country is about 90 lb. of coal per bbl. of clinker, the calorific value of the difference between this figure and the one just given being lost as sensible heat in the discharged clinker and chimney gases and by radiation and conduction from the kiln shell. Waste of fuel of this magnitude should certainly appeal to the fuel engineer as well worthy of attention, particularly if he considers the magnitude of the industry. In 1910 this country made nearly 70,000,000 bbl. of cement. It is only recently that intelligent attempts have been made to reduce the heat losses of the kiln, or to utilize the waste heat in other operations. A feeble attempt has been made in

[1]The Rotary Cement Kiln, by Ellis Soper, published in The Journal for October, 1910.

this country to pass the hot chimney gases (temperatures averaging 500 deg. cent.) through the driers and so eliminate the extra fuel required in that part of the plant. Such installations are very successful. The regeneration of the heat in the discharged clinker by passing it through an under-cooler and preheating the incoming air has not proved satisfactory in many installations because of the stupidity of the operators. Where properly run, this system is saving hundreds of tons of coal per year. The main trouble has been that the kilns became too hot and the clinker stuck to the sides, all because the kiln manager did not deem it necessary to cut down the fuel when heat units were fed in another manner. German cement manufacturers used both the dryer and the under-cooler with their kilns almost from the introduction of the rotary type. It is only since the publication by the author of figures on radiation from kilns and the means of reducing such losses, that attempts have been made to save fuel by the installation as a backing to the usual kiln lining of a new heat insulating material.

27 It is not impossible to conceive of the use of a different and more efficient type of furnace than the rotary kiln for performing the clinkering operation. Surely fuel engineers have a prize well worth striving for when one considers that a saving of 10 to 15 lb. of coal per bbl. of clinker means a saving of three-quarter of a million dollars annually to the cement industry.

28 The clinker, after leaving the kiln, is passed through a series of cooling devices to dissipate quickly the heat it contains, and is then stored in heaps in the weather to age. Cement that has been underburned or improperly mixed so that it contains free lime will not pass the boiling test. If allowed to remain in the weather for some time so as to slake this lime and even lose some of it by solution, the cement prepared from such weathered product is generally of improved quality. The aging of clinker renders it softer and more easily ground, increasing the output of the grinding mills as much as 50 per cent. The elevators and overhead devices needed to handle such a storage are not expensive or complicated. The increased capacity of the grinding machines more than off-sets the power required by the conveying and storage machinery, and it is believed that the consequent ability to grind finer also offsets the bad effects of any uncombined lime which may be present.

29 After being recovered from the aging heaps the clinker passes into the final grinding department of the mill. This is similar to the raw grinding department, with the omission of the gyratories and dry-

ers. Gypsum is mixed with the clinker and the mass then passes to the grinding mills to be again reduced in size. As we have seen that clinker may lie exposed to the weather without taking up water, there must be a maximum size of particle which will combine it with water. This has been variously placed at about 150 mesh size, all particles coarser than that being inert in the finished cement. For this reason it is necessary to grind so that the greater proportion of the product will again pass through the 200 mesh screen. After this grinding the cement passes to the stock house, where it is stored for packing and shipment. It is now packed by automatic weighing and packing machines, in barrels and bags, the latter predominating.

30 It is not possible here to take up the important subject of conveying machinery as applied to the cement mill. Practice has greatly standardized itself in this respect into the use of buckets for elevating, air not proving successful. Lump material like clinker is carried on belts or by drags, and the screw conveyor has no great competitor in the conveying of fine material.

31 The power required for driving the mill varies very much with the type of installation. With the old shaft drive it was not infrequent to use $1\frac{3}{4}$ h.p. per bbl. of output per day. Some of the new motor-driven plants use as low as $\frac{2}{3}$ h.p. per bbl. per day, and the average throughout the country is not far from $1\frac{1}{4}$ h.p. With the decreasing profit in cement manufacture the difference between the minimum and the average power requirements as given above should be sufficient to cause a remodelling of power plants and transmission machinery in the older mills. The gas engine should find a growing field in this industry because the individual machines lend themselves so readily to motor driving. The labor requirements of the various mills seems to run parallel with the power requirement. In the older mills 8 bbl. of cement per day per man employed was a good average, while the newer mills are producing 16 bbl.

32 Cost figures are difficult to obtain in any privately controlled and competitive industry, and the cement industry is no exception. In a recent presidential address before a scientific society the cost of cement production was placed at 12 lb. for 1 cent, or 33 cents per bbl. Where such figures were obtained is a source of wonder to the author, unless it was from the published figures given some years ago for a western plant which is now in receivers hands and has not been operated for many years. No mill in this country is producing at this figure, which is not large enough to include fuel and labor costs alone at the majority of mills in the country. The Lehigh region is pro-

ducing cement as cheaply as any district in the country and we have to strive hard to cut the total cost at the mill below 55 to 60 cents per bbl.

33 In the above brief review of the industry the author trusts that he has considered a few of the problems that are confronting cement manufacturers. It will readily be seen that they are almost wholly of a mechanical nature and will offer sufficient inducements to attract the members of such a society as this to coöperate in their solution.

MILLING CUTTERS AND THEIR EFFICIENCY

By A. L. DeLeeuw

ABSTRACT OF PAPER

Observations of present day practice and a number of experiments point to the fact that better results can be had from milling cutters by increasing the tooth space and depth. A number of cutters constructed along these lines were tested and it was found that they have a number of points in their favor among which are less consumption of power, a greater amount of work done for one sharpening and a greater number of possible sharpenings per cutter. A change in the form of chip breaker made it possible to use cutters with chip breakers for finishing, as well as for roughing. It was further found advisable to use a special kind of key, here described, for heavy work. Finally, this paper describes a new style of face mill and what is called a helical mill.

A number of diagrams are presented showing the relative efficiency of different styles of mills for removing a given amount of metal. In general, attention is called to the possibilities which lie in a more scientific construction of milling cutters and the desirability of discarding our ideas of milling cutters, which are largely based on conditions no longer existing.

MILLING CUTTERS AND THEIR EFFICIENCY

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Member of the Society.

The amount of metal which a machine tool can remove in a given time is limited by the strains caused by the cut. Great hardness of the material to be cut, or a dull tool, will severely strain the machine and so reduce the section of the chip, even if the machine is rigidly constructed and well supplied with driving power. It is therefore of the greatest importance to analyze carefully all the conditions which cause heavy strains so that they may be obviated or reduced to the lowest possible limit.

2 This limitation of the cutting capacity occurs in all metal cutting machines, although to a varying extent. While it is possible to increase the driving power of most machines ad-libitum, and almost any amount of metal can be put into machine elements to give them rigidity, there are certain classes of machines where practical considerations limit such increase of power and strength. This is especially true in machines where the main elements have to be adjusted and handled with great frequency. The knee-and-column type of milling machine owes its success, to a large extent, to the ease and rapidity with which it can be manipulated and it is doubtful if it will ever be possible to increase the dimensions of the parts much beyond the present sizes, without losing the benefits of the peculiar construction of this type of machine. In order to increase the capacity of this type of milling machine, it becomes necessary to reduce the strains set up by the cut and there are only two elements which can be modified to accomplish this result. These are the hardness of the metal to be cut and the cutting qualities of the milling cutter. As it is impossible to control the first of these, the only avenue left for improvement leads in the direction of the milling cutter.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

3 Experiments carried on at the works of the Cincinnati Milling Machine Company and extending over several years, starting with some isolated and almost desultory trials, and gradually becoming a series of carefully planned experiments, have led to results which are believed to be of general interest. These tests embraced spiral mills, end mills, both of the shell end-mill type and the spiral taper-shank type, side mills, slitting saws, face mills, and a new type of mill which for lack of a better name is called here a helical mill.

4 The action of the ordinary milling cutter is not a true cutting action, as it is commonly understood. By a true cutting action is meant the driving of a wedge-shaped tool between the work and the chip and although this definition is not based on a generally accepted meaning of the term it is believed that it expresses fairly well what most mechanics understand by cutting. Practically all milling cutters have their teeth radial and this, of course, excludes the possibility of driving a wedge between chip and work. The tooth compresses the metal until it produces a strain great enough to cause a plane of cleavage at some angle with the direction of the cutter. It then begins to compress a new piece, push it off, and so on. This at least *seems* to be the action of the cutter, judging by the form of the chips. These chips are in the form of needles or small bars.

5 The chip taken by a milling cutter varies very materially from those taken by a lathe or planer tool. These latter tools make chips of uniform section, whereas the section of a milling chip increases from zero to a maximum.

6 Fig. 1 shows a milling chip as it would appear, if no compression or distortion took place. The proportions are very much exaggerated, so as to bring its typical shape clearer into view. The width AB at the top is equal to the feed per tooth. The height BC is the depth of cut. The length BD is the width of cut. The section $MNOP$, shown half way on the chip, is a normal section and a measure of the amount of work which was done at the time the cutter passed the point M.

7 Fig. 2 shows the action of a milling cutter, with center O, when the cutter is rotating and the work is feeding at the same time. The tooth AB sweeps through the path BC. When the point B has reached the position B_1 a new tooth starts cutting. By this time O has advanced to position O_2, and the new tooth A_2 B_2 is not yet in a vertical position, when the point B_2 touches the work. When the cutter revolves, this point B_2 must penetrate into the work and compress the metal of the work. The result will be spring in the arbor. When this

spring has assumed certain proportions, the blade or tooth begins to remove a chip. This may be assumed to take place in the position B_3, the tooth simply gliding over the work from B_2 to B_3. This action must necessarily be very harmful to the cutter, and, it was believed that this, perhaps more than any other action of the cutter, caused its dulling. It would be especially severe with light cuts, as a relatively small amount of spring would allow the point B_2 to travel through a large arc. It would be quite possible that a tooth should fail entirely to take a chip, and that the succeeding tooth would take a chip of double the amount.

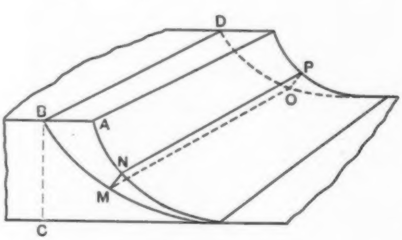


FIG. 1

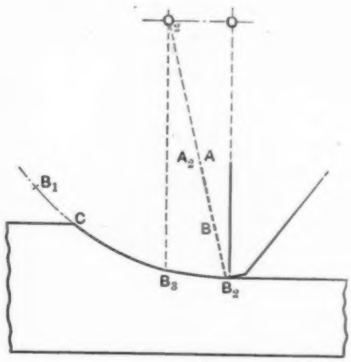


FIG. 2

FIG. 1 METAL CHIP ASSUMED TO BE PRODUCED BY MILLING-CUTTER WITHOUT DISTORTION

FIG. 2 DIAGRAM TO ILLUSTRATE ACTION OF MILLING-CUTTER

8 This peculiar action of the milling cutter is inherent in its construction and cannot be avoided. The question then is how to minimize these harmful results.

9 Another feature, which limits the ability of a milling cutter to remove metal, is the proportion between the chip to be removed and the amount of space between two adjoining teeth. Such a limitation does not exist with lathe or planer tools, where the chips have unlimited space in which to flow off.

10 That this proportion between chip and chip space actually does form a limiting condition is well known and was brought most forcibly to the writer's attention when a large and powerful machine stalled, taking a cut in cast iron about $1\frac{1}{2}$ in. wide, $\frac{3}{16}$ in. deep and $12\frac{1}{2}$ in. feed per minute. Several times this amount of metal can be easily removed by the same machine, without sign of stress; yet the machine was incapable of removing more than 3 cu. in. of cast iron

per minute with this cut. Investigation showed that the amount of cast iron removed per tooth was sufficient to fill the chip space completely, and from that moment the action was like trying to push a solid bar of steel through a piece of cast iron. Another cutter, with more chip space, removed the same amount of metal with only a fraction of the power of the machine.

11 Similar instances occurred with gangs which had been in use a long time, and which had been ground down to such an extent that the chip space was materially reduced. This, combined with the fact that higher developed milling machines led the shop to coarser feeds, showed that the ability of the machine to remove metal was not only governed by its power, but to an equal extent by the peculiarities of the milling cutter.

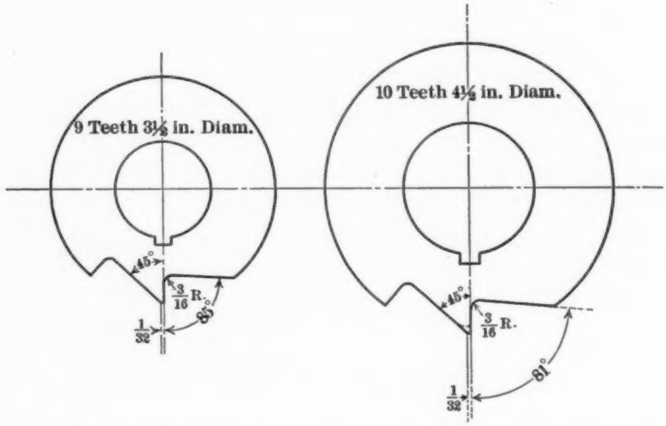


Fig. 3 Form of Spiral Milling-Cutters now used by the Cincinnati Milling Machine Company

12 The foregoing considerations led to a gradual evolution of spiral milling cutters. At first, the number of teeth of spiral mills was only slightly diminished, as it was thought that some element which was not considered might affect the result. Gradually the spacing was increased and the cutters, as now used, have taken the forms shown in Figs. 3 and 4.

13 Two standard sizes are used, although other sizes are required for special cutters and special gangs. The standard diameters are 3½ in. and 4½ in. The 3½-in. diameter cutters are made with nine, and the 4½-in. diameter cutters with ten teeth, which corresponds to a spacing of about 1¼ in. The point of the tooth has a land of $\frac{1}{32}$ in.,

and the back of the tooth forms an angle of 45 deg. with the radial line. The chip space is approximately four times as great as in the usual standard cutter of the present time and is formed with a $\frac{3}{16}$-in. radius at the bottom.

14 Though not directly connected with the foregoing, attention should be called to the fact that present practice calls for arbors which are too small. In the cutters shown here, the $3\frac{1}{2}$-in. cutter is made with $1\frac{1}{2}$-in. and $1\frac{3}{4}$-in. arbor, and the $4\frac{1}{2}$-in. cutter with $1\frac{3}{4}$-in. and 2-in. arbor.

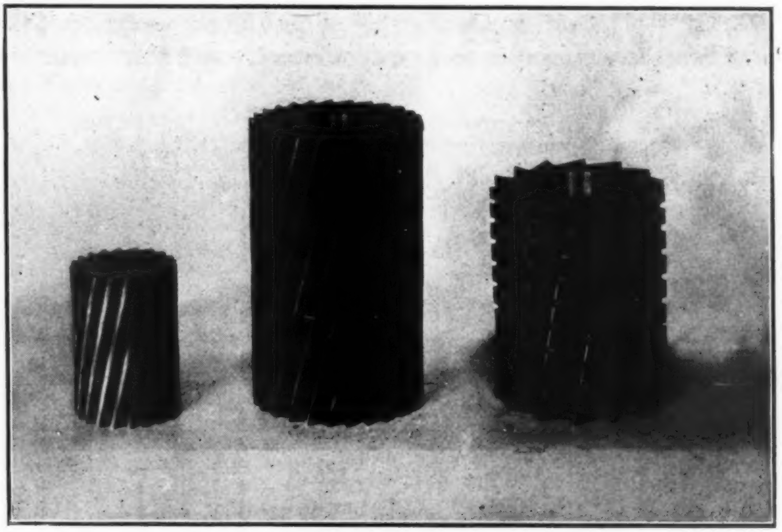
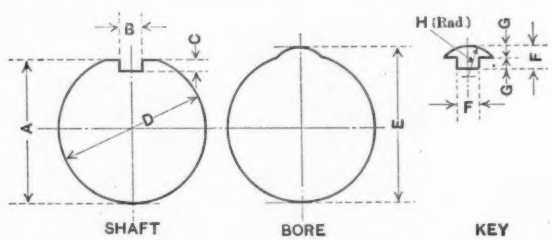


FIG. 4 COMPARISON OF OLD AND NEW STYLE SPIRAL MILLS

15 It is often very difficult to remove cutters from an arbor after they have done heavy work. It is frequently necessary in such cases to press the arbor out of the cutters. This sticking of the cutter is caused by the burring up of the key, and often the keyway in the arbor. For this reason, keys are used for gangs of cutters as shown in Fig. 5. A flat is milled on the arbor, and the keyway milled central with this flat. The flat portion of the key presses against the flat part of the arbor, and this effectively prevents burring. Cutters which are held on the arbor with such a key can always be very readily removed, even after prolonged and hard work. The keys are made out of a piece of round stock, grooved at both sides and then sawed apart.

16 Very satisfactory results were obtained with these cutters. Figs. 6, 7 and 8 show the results of tests made with cutters with $\frac{5}{8}$ in., $\frac{7}{8}$ in. and $1\frac{1}{8}$ in. spacing. Cuts were taken on cast-iron test blocks as shown in Fig. 9. The cross-sectioned part of the test block was milled out. A series of tests was made on the left-hand half of the block with one kind of cutter and on the right-hand half with another cutter. It will be noticed that the same amount of power is required to take a cut $\frac{1}{4}$ in. deep and with 10.4 feed with a cutter of $\frac{5}{8}$ in. pitch; and a cut $\frac{1}{4}$ in. deep and with 13.5 feed but with a cutter of $1\frac{1}{8}$ in. pitch.

17 It was not safe to assume that all test blocks would be of the same hardness. In order to correct whatever error there might be



A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
0.973672	$\frac{5}{32}$	$\frac{5}{64}$	1	1.05179	$\frac{5}{32}$	$\frac{5}{64}$	$\frac{11}{64}$
1.03779	$\frac{5}{32}$	$\frac{5}{64}$	$1\frac{1}{16}$	1.11592	$\frac{5}{32}$	$\frac{5}{64}$	$\frac{11}{64}$
1.21875	$\frac{3}{16}$	$\frac{3}{32}$	$1\frac{1}{4}$	1.3125	$\frac{3}{16}$	$\frac{3}{32}$	$\frac{1}{4}$
1.4543	$\frac{1}{4}$	$\frac{1}{8}$	$1\frac{1}{2}$	1.5793	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{21}{64}$
1.7111	$\frac{1}{4}$	$\frac{1}{8}$	$1\frac{3}{4}$	1.8361	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{21}{64}$
1.94734	$\frac{5}{16}$	$\frac{5}{32}$	2	2.10359	$\frac{5}{16}$	$\frac{5}{32}$	$\frac{13}{32}$

Fig. 5 Shape and Dimensions of Keys used for Milling-Cutter Arbors

on account of unequal hardness of the test blocks, hardness tests were made of the different blocks. These consisted in taking a cut $\frac{3}{16}$ in. deep and with various feeds on each one of the blocks, and finally a check test on the first block, to make sure that the cutter had not appreciably dulled.

18 It will be seen from these diagrams that there is a large increase in the amount of metal which can be removed with the same amount of horsepower, by using these wide-spaced cutters; and that, therefore, the scope of the knee-and-column type of milling machine has been enlarged without increasing sizes or weight of parts and thus decreasing the handiness of the machines.

19 Though increased capacity for removing metal is one of the main advantages of this form of cutter, there are others of consider-

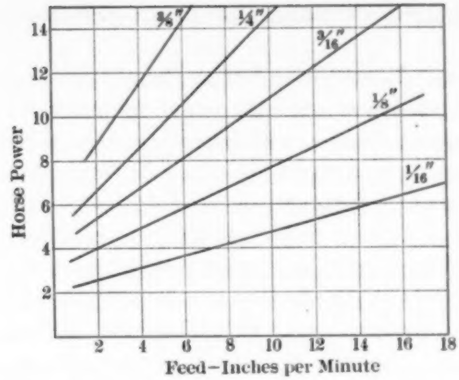


Fig. 6 Tests of Spiral Nicked Milling Cutter 3$\frac{23}{32}$ in. Diameter; 18 Teeth and about $\frac{5}{8}$ in. Pitch. Cutting Cast Iron Corrected for Hardness. Width of Cut 6 in.

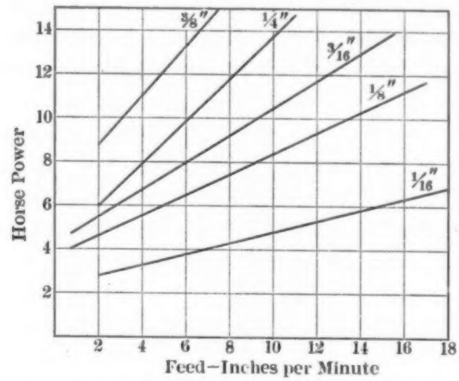


Fig. 7 Tests of Spiral Nicked Milling-Cutter 3$\frac{1}{12}$ in. Diameter; 14 Teeth and about $\frac{3}{4}$ in. Pitch. Cutting Cast Iron, Corrected for Hardness. Width of Cut 6 in.

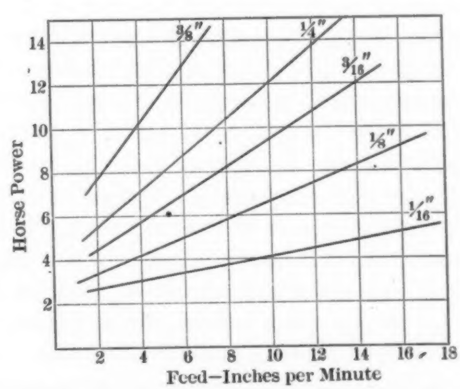


Fig. 8 Tests of Spiral Nicked Milling-Cutter 6 in. Diameter; 16 Teeth and about 1$\frac{1}{8}$ in. Pitch. Cutting Cast Iron, Corrected for Hardness. Width of Cut 6 in.

able importance. It was found that for roughing on the ordinary work in the shop a cutter with the wider-spaced teeth would remain sharp for a longer period, notwithstanding that feeds had been increased. The system of the Cincinnati Milling Machine Company requires all gangs and cutters to be re-sharpened after a lot of pieces has been milled. It used to be necessary, at least on the larger lots, to re-sharpen the gang once and sometimes twice for one lot, or, if this was not deemed advisable, the feed had to be reduced for at least part of the pieces, in order to make the cutter last during the entire lot. In all cases where the wide-spaced cutters were used, the entire lot was run through without re-sharpening the cutter or reducing the feed; and it should be kept in mind that this feed was from 25 to 100 per cent greater than previously used. There is no case on record where the cutter or gang was dull at the end of the lot, so that our observations as to the endurance of the cutters are incomplete. However, it is perfectly safe to say, that in all cases under observation the cutter

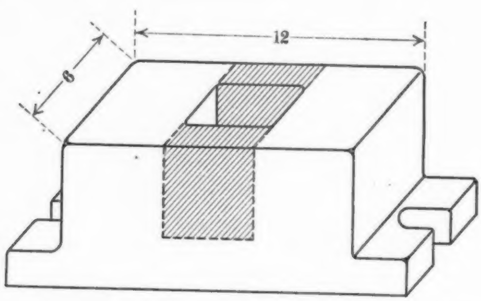


FIG. 9 TEST BLOCK USED IN TESTING CUTTERS WITH DIFFERENT SPACING OF TEETH

maintained its sharpness longer; that in a great many cases double the amount of work could be done without re-sharpening; and that there is good reason to believe an even greater gain than this was obtained.

20 A further advantage is, that as these cutters have approximately only half the number of teeth of what is now considered a standard cutter, the time for re-sharpening is only half as much.

21 It was pointed out that the ratio of pitch to depth is practically the same as in the present standard cutter, so that the depth of tooth is practically doubled and this cutter can be sharpened much more frequently than the present standard cutter. Consequently the life of the cutter has been much increased, probably more than doubled.

22 A glance at the drawing of these cutters gives the impression that the teeth are weak and the writer has watched this feature with great care. The cutters themselves, however, do not give this impression; on the contrary, they look stout and well proportioned. They have been subjected to the heaviest class of work and many times were purposely abused in order to find their weak points; yet there is no case on record that any of them have broken although they have been used for more than two years and all breakages of cutters are carefully noted. On the other hand, breakages of the old cutters are not at all infrequent.

23 Though these cutters are capable of removing metal more rapidly than the older type of cutter there are many cases where this feature cannot be taken advantage of, as, for instance, where light work is to be done or a small amount of stock to be removed. In such cases, however, the metal is removed with less power and consequently with less strain on the machine and the life of the machine is lengthened without limiting its output.

24 With the wide spacing of the teeth it may seem that there would be cause for apprehension as to the action of the feed. It seems as if the feed would be liable to act with jerks. This, however, is not the case. On the contrary, the feed is smoother and there is less of a jerk when the cutter first strikes the work, probably because there is less spring in the arbor and less tendency for the cutter to ride over the work, as will be explained later in connection with the description of cutters.

25 In connection with this, it is interesting to note that when cast iron is milled by these wide-spaced cutters, it appears to be very soft and when the same piece is milled by an old-style cutter, it appears to be much harder. When using the wide-spaced cutter, there is a notable absence of jerking, chattering and of the peculiar singing noise which is so often noticed on milling machines.

26 There is, of course, a difference in the hardness of different pieces of cast iron, and many recommendations as to the proper feeds and speeds for milling cast-iron work, made by the writer for the his Company, were looked at askance. The impression seemed to prevail that feeds and speeds which were possible on American iron, were out of the question on European iron, (especially English and German); and again, that feeds and speeds proper for western American iron were not suitable for eastern iron. To test the truth of the matter, a number of bars of cast iron were obtained from different foundries in America, England, France and Germany.

These bars covered a great many mixtures and makes, and the difference between English and American, or German and American iron, or between eastern American and western iron, was found to be no greater than that between different specimens of western American iron. Even German Spiegeleisen, famous for its hardness, cut just as freely as soft western iron, and required but little more power. However, it did require more clearance, wide spaces, and a low speed.

27 These wide-spaced cutters were originally intended for roughing operations only, but the very satisfactory finish obtained when roughing led to the use of the cutters for finishing also. If there is any difference at all in the finish produced, the advantage is on the side of the wide-spaced cutter. The fact that this wide-spaced cutter will cut a greater number of pieces without dulling, means, of course, that the average finish of an entire lot is better.

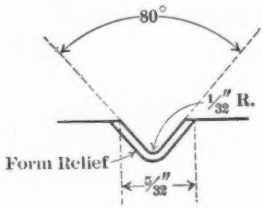


FIG. 10 CHIP BREAKER, DOUBLE SIZE

28 It is generally believed that for finishing alone a milling cutter should be used without chip breakers, the effect of the chip breaker being to scratch the surface. To overcome this trouble, chip breakers are made as shown in Fig. 10 with clearance at both corners. This prevents the tearing up of metal with the result that a cutter with these chip breakers produces as good a finish as one without chip breakers.

29 It should be pointed out that this form of chip breaker has an advantage also for roughing cuts. The point of the cutter, where the unrelieved side of the chip breaker drags over the work, is the first point to give out. Making the chip breaker with clearance on both edges prolongs, therefore, the life of the cutter.

30 One of the great advantages of this form of chip breaker is, that one gang can be used for both roughing and finishing. A great many, if not most milling operations, call for two chuckings, one for roughing, and one for finishing. This will be found to be necessary

wherever much metal is to be removed, on account of distortion caused by the cut, the heavy clamping required, heating, spring of arbor or fixture and the unbalanced condition of the work after the scale has been removed on one side. In order to do the roughing as rapidly as possible chip breakers are required; and in order to get proper finish, it has heretofore been necessary that the finishing gang be without chip breakers. It paid, therefore, to have two gangs whenever the number of pieces to be milled was sufficiently large, but this involved considerable extra expense for cutters. The new form of chip breaker, however, permits using one gang for both finishing and roughing.

31 It is a common belief that better finish can be obtained with teeth closely spaced, but experience with the wide-spaced cutter shows that there is no ground for this belief. The grade of finish may be expressed by the distance between successive marks on the work. These marks are revolution marks and not tooth marks. It is practically impossible to avoid these revolution marks. They are caused by the cutter not being exactly round or quite concentric with the hole, by the hole not being of exactly the same size as the arbor, by the arbor not being round, by the straight part of the arbor not being concentric with the taper shank, by the taper shank not being round or of the same taper exactly as the taper hole in the spindle, by this taper hole being out of line with the spindle, by looseness between the spindle and its bearings, etc. Each of these items is very small in any good milling machine; yet the accumulation of these little errors is sufficient to cause a mark and this mark needs to have a depth of only a fraction of a thousandth of an inch to be very plainly visible. As these marks are caused by conditions which return once for every revolution of the cutter, it is plain that the spacing of the teeth can have no effect on the distance between them and, therefore, on the grade of finish.

32 To test this still further, two cutters of the same size exactly were placed side by side on an arbor. The cutters were ground together so as to be sure they were of equal diameter and they were ground on the arbor so as to be sure that the error would appear simultaneously for both cutters. A block of cast iron was finish-milled with these cutters in such a way that each cutter would sweep half the width of the block. The same number of marks appeared on both sides of the block, and these marks were exactly in line with each other, as might have been expected. The grade of finish was the same for both sides. It was neglected to mark the two sides of

the casting to show which cutter was operating. After this test, all of the teeth but one of one of the two cutters were ground lower, so as to be out of action entirely, leaving only one tooth of the one cutter operative. Another cut like the first one was taken over the same block, and again the finish appeared the same on both sides. There

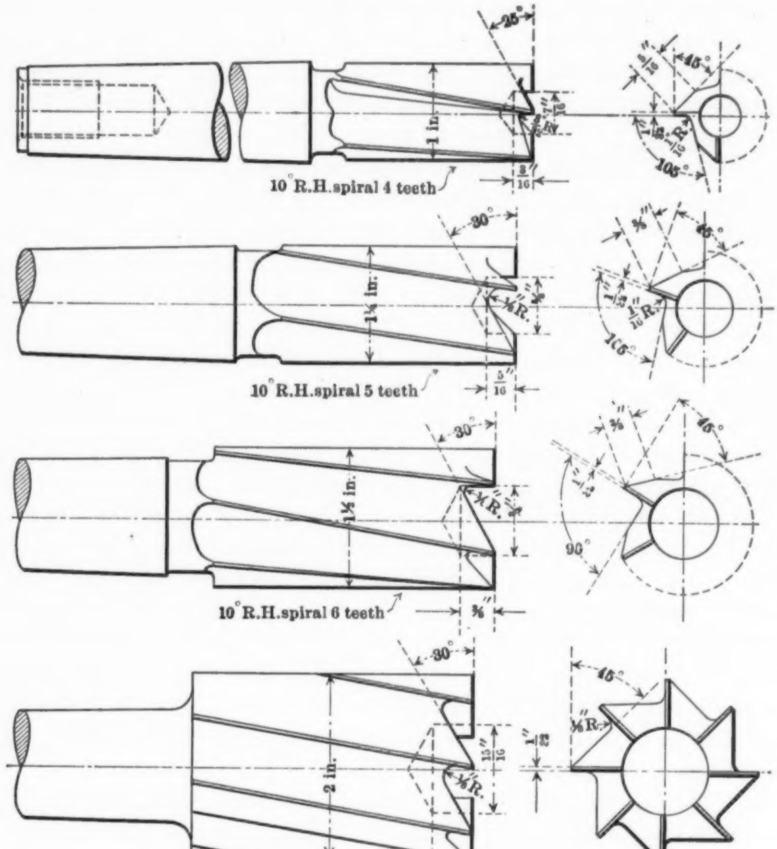


FIG. 11 NEW TYPE OF TAPER SHANK END MILLS

was a difference of opinion between different observers as to which side was cut by the single tooth. By close observation, however, a difference could be detected when light fell on the work in a certain direction, under which conditions one side showed more gloss than

the other. Straightness, flatness and smoothness to the touch were exactly the same for both sides, notwithstanding that one cutter had one tooth only and the other fourteen teeth. Though it is not recommended here to use cutters with one tooth only for finishing, the foregoing test shows plainly that there is no merit in fine spacing. Attention is again called to the fact, that even though the finish on a single piece *might* be better with more teeth in action, the *average* finish for an entire lot of pieces is better with less teeth.

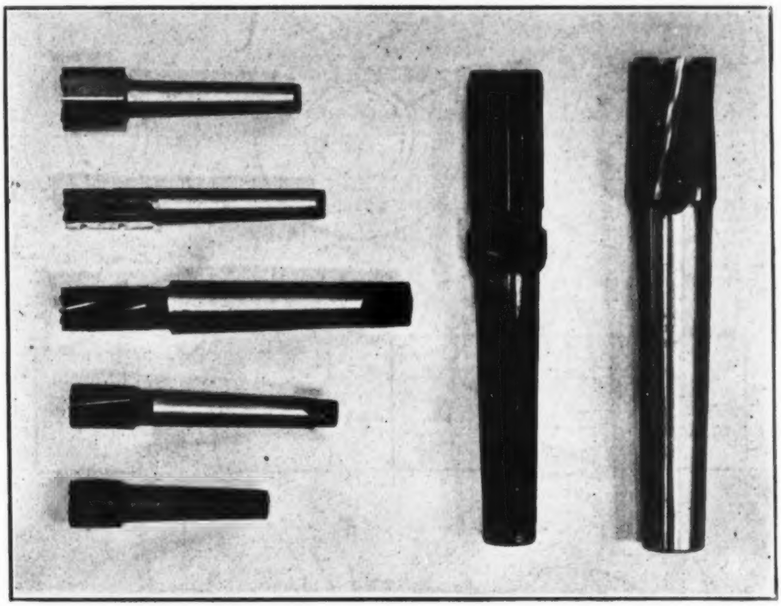


FIG. 12 COMPARISON OF OLD STYLE AND NEW STYLE END MILLS

33 Figs. 11 and 12 show the end mills which are now considered standard by the Cincinnati Milling Machine Company and which fill practically all requirements. They are made in sizes of 1 in., $1\frac{1}{4}$ in., $1\frac{1}{2}$ in. and 2 in. in diameter, the smallest with four, and the largest with eight teeth. It will be noticed that in order to preserve the strength of the teeth it is necessary to mill the back of the teeth of the three smaller sizes with two faces. A number of tests have been made with these cutters, but no comparative tests as to power consumption. Their action is remarkably free. This was clearly demonstrated by the following experiment: A 2-in. taper shank end-

mill milled a slot $1\frac{1}{16}$ in. deep in a solid block of cast iron at a rate of 6 in. per min. The block was clamped to the table of the milling machine and the knee was fed upward. Under these conditions the

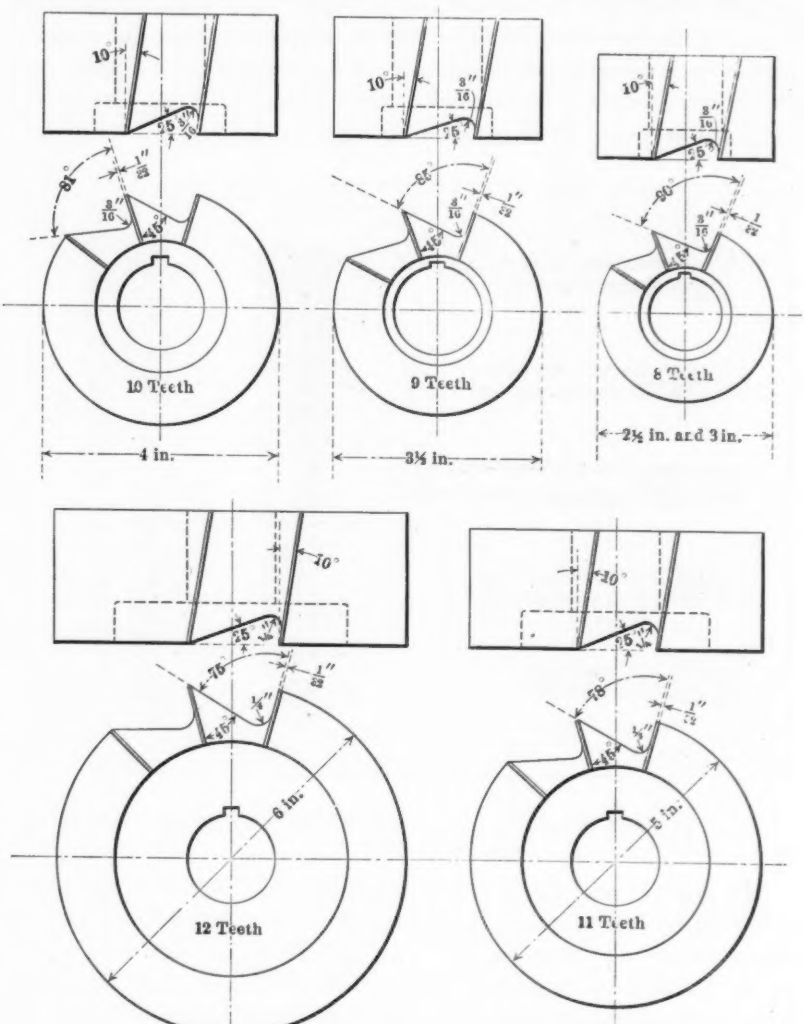


FIG. 13 NEW TYPE OF SPIRAL SHELL CUTTERS

chips did not free themselves from the cutter, but were carried around and ground up. The cutter was cutting over half its circu nference. These two conditions combined make the task for the milling cutter

about as difficult as is imaginable. There was, however, no sign of choking and the power consumption was not higher than it would have been with a spiral mill under ordinary conditions. The same cutter would remove from the end of the casting a section 1½ in. wide

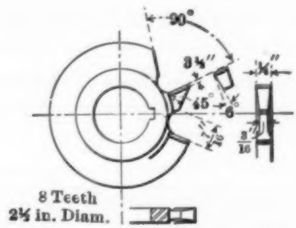


Fig. 14*a* Details of New Type of Side Mills

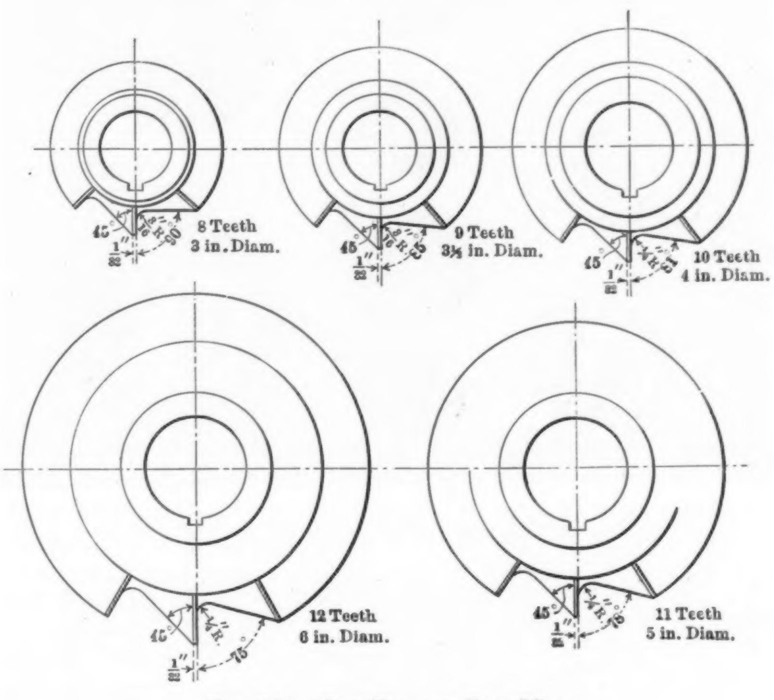


Fig. 14*b* New Type of Side Mills

and 1½ in. deep. Under those conditions, the chips would free themselves from the cutter and these chips were rolled up in pieces much like the chips obtained from a broad planer tool, when taking a finish-

ing cut. This cut was taken with a feed of 11 in. per minute. Another similar cut, but 1 in. and 1½ in. in section was taken with a feed of 33 in. per minute. Similar, though much lighter cuts were taken with ordinary end mills, and in the same piece of cast iron. Again the cast iron seemed to be very hard, and became glossy when cut with an ordinary cutter, but appeared to be soft when cut with the wide-spaced cutter.

34 Fig. 13 shows the shell end mills of the wide-spaced type, which are now considered standard for their use by the Cincinnati Milling Machine Company.

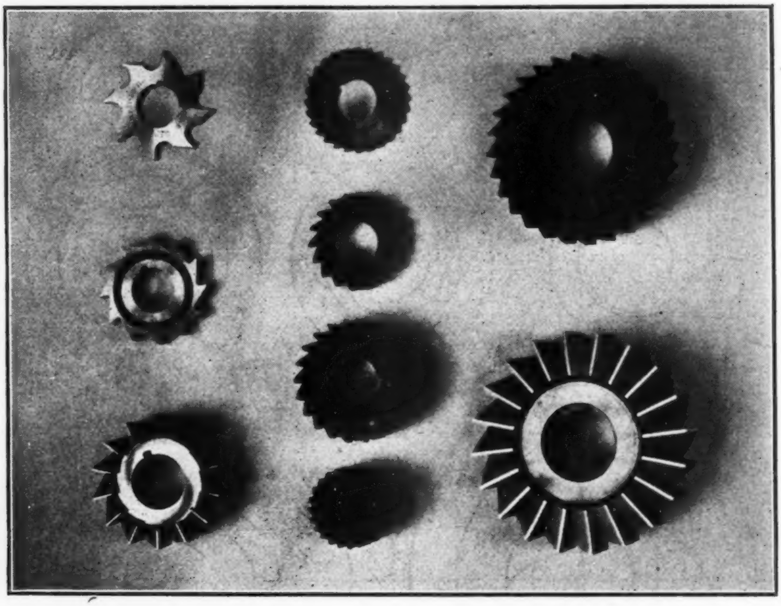


FIG. 15 COMPARISON OF SIDE MILLS AND SLOTTING MILLS

35 Figs. 14*a* and 14*b* show the side mills and Fig. 15 gives a comparison of the new and old-style side mills and slotting mills.

36 Face mills have also undergone a gradual evolution and they are now used by the company and catalogued, though not made by them for use of customers, as shown in Fig. 16. Fig. 17 shows a cutter of a design now generally considered to be standard. In this latter design, the blades are spaced 1 in. apart, or approximately so; they are set radial, and have no means to keep them from pushing back except the regular holding means. The wide-spaced face mill, on the other

hand, has the blades spaced 2 in. apart. They are set at an angle of 15 deg. with the radial line, and are backed by a backing ring with a set screw for each blade. These set screws allow the blade to be adjusted, besides forming a stop against upward movement under pressure. A face mill may be considered as a planing tool moving in a circular path. The cutting edge, therefore, is axial and not radial. To set the blades at an angle with the axis does not produce rake. The wide-spaced face mill shown here has rake, because the blades are set at an angle with the radial line.

37 It will be noticed that the blades are set at an angle with the axis. It will further be noticed, in the enlarged view of the blades, showing the rounded corners, that the corners are not provided with a round, but rather with three faces, which together approximate a curve. It is to offset the effect of this round that the angle with the axis is introduced. In Fig. 18 a new-type face mill is shown at the left and at the right a mill of the old or regular type.

38 However accurately a milling machine may be built, the spindle is not exactly at right angles with the table. The amount of variation from the right angle is very small in a properly built machine, but some variation exists. Besides, this variation is liable to become greater when the machine wears. The result is, that when feeding in one direction the leading teeth of the cutter dig deeper into the work, leaving the other side of the cutter entirely clear, but when feeding in the opposite direction the opposite takes place, which makes the teeth drag over the work. In order to provide the teeth with clearance, the back end of the tooth is ground away at an angle of three to five degrees.

39 It will further be noticed, that there is a land of $\frac{3}{16}$ in. only where the blade is straight. It is the excess of width of the cutting blades which is liable to cause chatter. Strange as it may seem, this chatter is more pronounced with a light than with a heavy cut. It is not meant that there is actually chatter, but merely that when there is a tendency to chatter, the tendency is greater on a lighter cut. The cause is that the tooth does not enter the work but tries to ride over it. When the cutter has been lifted sufficiently, the pressure becomes great enough to make the blades enter. The next blade meets the same difficulty about entering, is lifted again, and so on. This action causes a series of radial chatter marks and is very much worse with wide blades than with narrow ones; and again very much worse with a large number of blades than with a few. A $\frac{3}{16}$-in. land proved to be an acceptable compromise, as a wider land would quickly

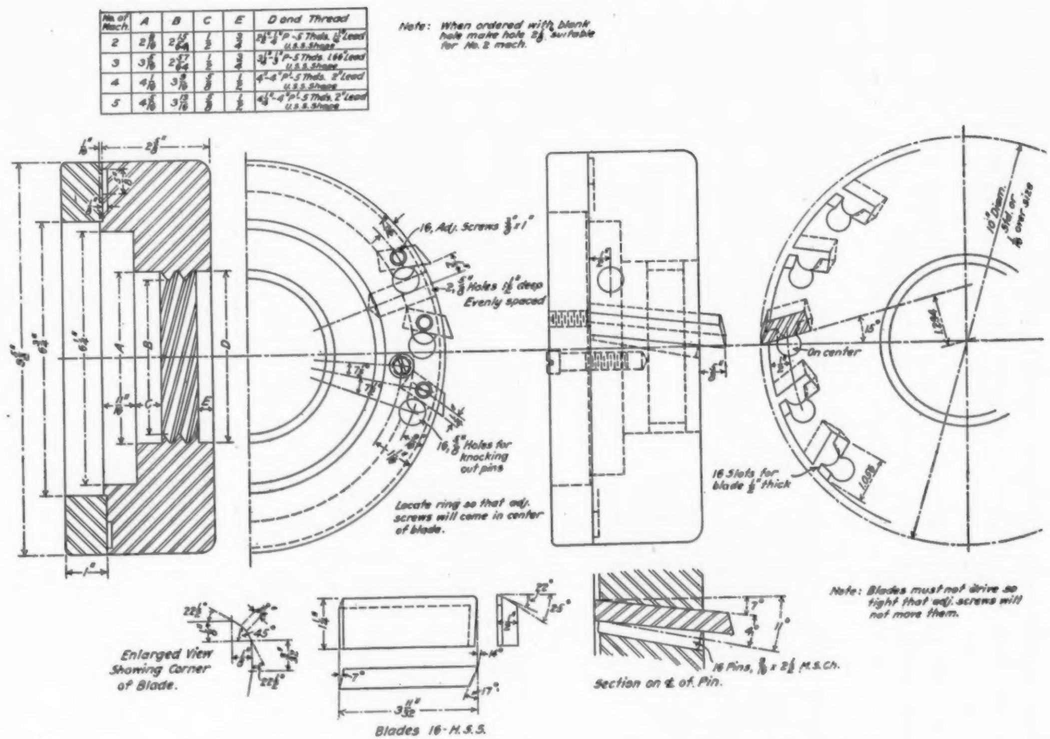


FIG. 16 TEN-INCH BLADE FACE MILL FOR HIGH-POWER MACHINES

dull the cutter, even if it did not make a chatter mark, while a narrower land would have the tendency to produce a scratchy finish.

40 In Fig. 19 is shown details of a helical cutter. These cutters consist of a cylindrical body, with two or three screw threads wound around them, the threads being of a section clearly indicated in the engraving. The helix is wound around the body with an angle of 69 deg. with the axis. The diameter is $3\frac{1}{2}$ in. and the lead of the helix $4\frac{1}{4}$ in. They are made in two styles, either single, or as interlocking right and left hand cutters. They are made with a rake of 15 deg.

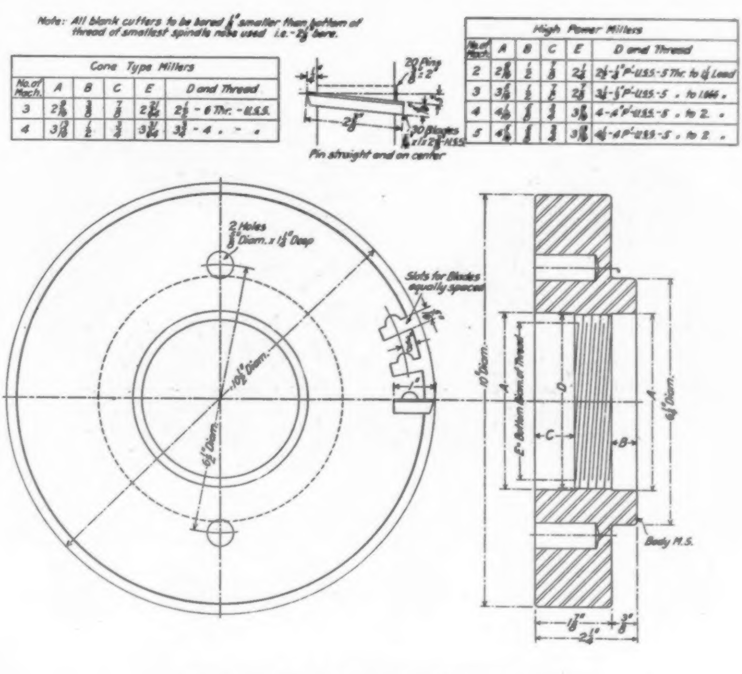


FIG. 17 FACE MILL OF OLDER TYPE

and clearance of 5 deg. when used for steel, and with a rake of 8 deg. and clearance of 7 deg. when used for cast iron. Their most distinguishing feature is, that they push the chip off in the direction of the axis of the cutter, or at right angles to the feed. The power consumption is extremely low for steel, but does not show up so favorably for cast iron. A roughing cut in steel requires only about one-third the power of an old-style spiral mill. Another distinguishing feature is, that this cutter does not make revolution marks but tooth marks. As

a result, a much coarser feed can be used for finishing. A cutter with three teeth will allow of a finish three times as fast as an ordinary spiral mill. Still another feature of this cutter is the entire absence of spring in the arbor when cutting steel. It is possible to take a finishing cut over a piece of steel, then return the work under the cutter and let the cutter revolve any length of time without producing a mark. Fig. 20 shows how this feature was made use of in the milling of steel test pieces.

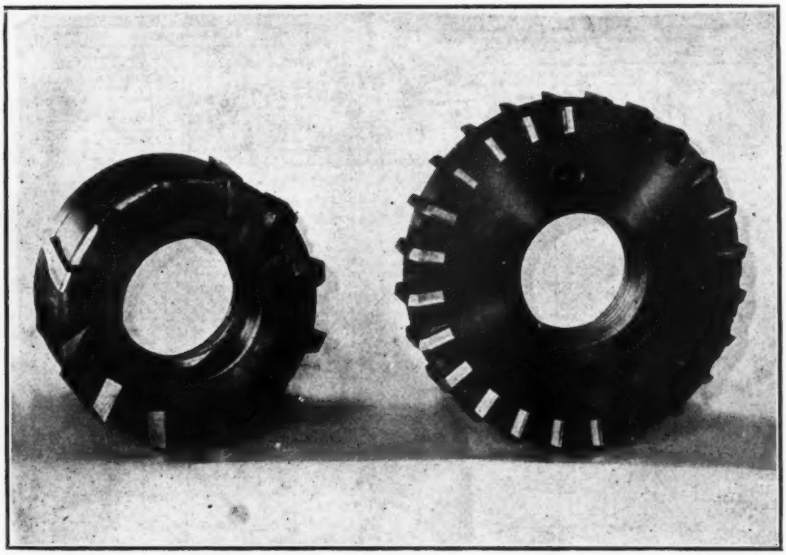


FIG. 18 COMPARISON OF HIGH POWER AND REGULAR FACE MILLS

41 It was originally thought that a single cutter of this description would do well for finishing, but not for roughing, on account of the excessive end pressure on the spindle, and the interlocking cutter was made to obviate this end pressure. However, it was found that this end pressure, though perceptible, was no disturbing element. Cuts which required 80 amperes with the interlocking cutter, required 85 amperes with the single cutter. In order to see if continued use of the single cutter would cause increasing friction at the spindle end, a great number of cuts were taken in as rapid succession as it was possible to adjust the machine for the next cut.

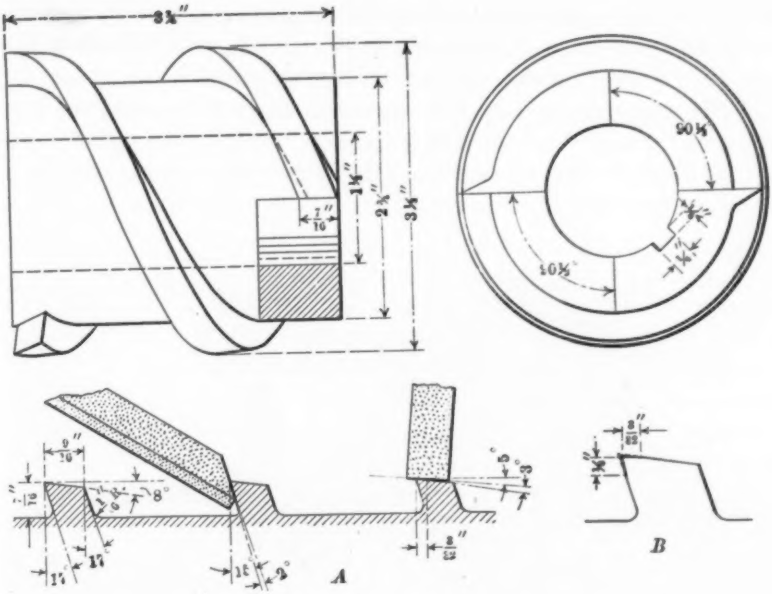


FIG. 19 DETAILS OF NEW TYPE OF HELICAL CUTTER

42 The fact that there is no spring in the arbor makes it possible to use the milling machine without braces in a great many cases where they would otherwise be needed.

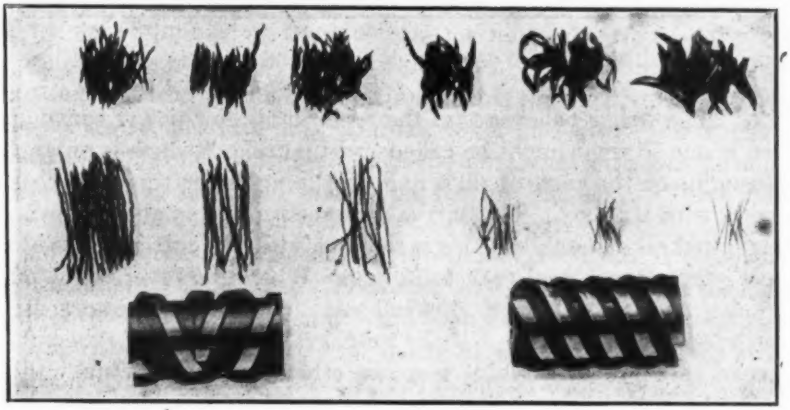


FIG. 20 HELICAL CUTTERS, SINGLE AND INTERLOCKED, AND CHIPS PRODUCED BY THEM

43 The chips come from the work in the form of gimlets as shown in Fig. 20. The back of the chip is polished or burnished, and a surface of the work shows no sign of tearing of the metal.

44 It was first believed that these cutters would work best at a high speed; but it was found that this was not the case. They produce the best results when run at the same number of revolutions as the ordinary spiral mill.

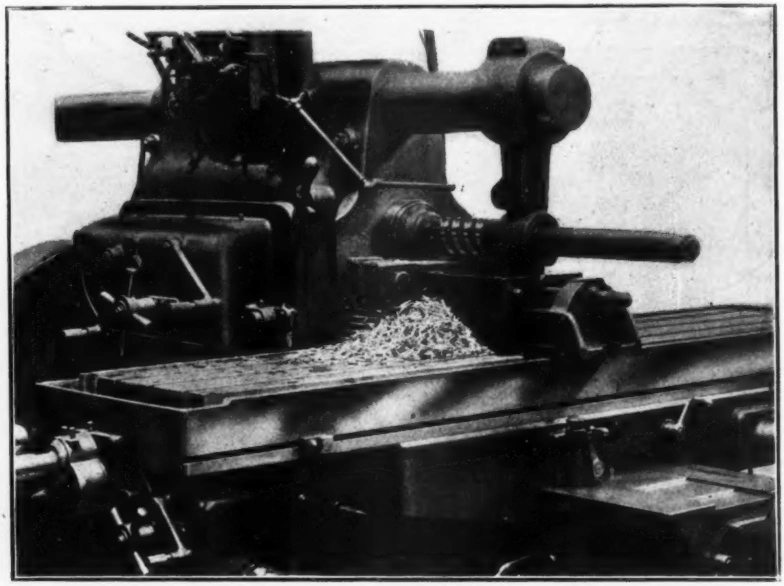


FIG. 21 HELICAL CUTTER AT WORK ON STEEL TEST PIECES

45 The writer believes that the remarkably low-power consumption is due to what might be called "virtual rake," which is an angle depending on the angle of rake, and on the angle the thread or tooth makes with the axis. This virtual rake becomes a small angle when the actual rake is small. This is the case with the cutter as used for steel, where the actual rake is 75 deg. Where, however, the angle of rake approaches 90 deg., the influence of the helix becomes very much less pronounced; and, if the actual rake were 90 deg., the influence of the spirality would be zero; in other words, the virtual would equal the actual rake. This may explain why the saving in power consumption is not so pronounced when cutting cast iron. It is believed that this saving of power would be equally great with cast

iron as with steel, if the same virtual rake could be obtained, and this supposition was borne out by a few tests made on cast iron with a helical cutter ground for steel. The fact, however, that the edge of the cutter would not stand up, made it impossible to extend the tests far enough to come to a safe conclusion.

46 Another reason which suggests itself to the writer, as to why the helical cutter shows less saving in power on cast iron than on steel, is the result of a series of tests made on cast iron and steel with spiral mills with and without rake, the rake being in all cases 9 deg. These cutters showed improved efficiency for steel and cast iron, but much more for the first than for the latter. A cutting tool must detach the chip from the work, bend the chip and at least partially break it up. When cutting steel, the radius of curvature of the chip becomes greater with increased rake and the extent to which the chip is broken up becomes less. Cast iron will stand much less bending before breaking, so that, even with increased rake, the chip is still broken up as before, and no saving in power can be effected in this part of the process.

47 Figs. 22 and 23 are diagrams comparing the performance of different styles of cutters for different materials and the different depths of cut. Fig. 22 gives a comparison with feeds of 4 in. per minute and Fig. 23 for 14 in. per minute. It will be noticed that all lines are practically straight with the exception of the line for the regular face mill when cutting machinery steel. This line makes a sharp turn. This is believed to be due to the fact that the blades of this face mill did not project far enough beyond the body. As cast iron chips were crumbled up the effect was not noticeable for cast iron, but became quite important for machine steel. Fig. 22 shows that for cutting cast iron the high-power face mill is the most efficient. Then comes the regular face mill, then the spiral mill with 1⅛-in. spacing, then the spiral mill with ¾-in., then the spiral mill with ⅝-in. spacing. The 5-in. and 3-in. end mills come last in efficiency. These mills are of the old type with relatively fine spacing.

48 The order of efficiency of the different cutters is somewhat different for machine steel. The helical mill comes first, then the high-power face mill, then the spiral nill with ¾-in. spacing (no tests were made with spiral mills with ⅝-in. and 1⅛-in. spacing on machine steel) and finally the regular face mill; but it should be noticed that, if the curve for this mill had continued the way it started, it would have been below the curve for a spiral mill.

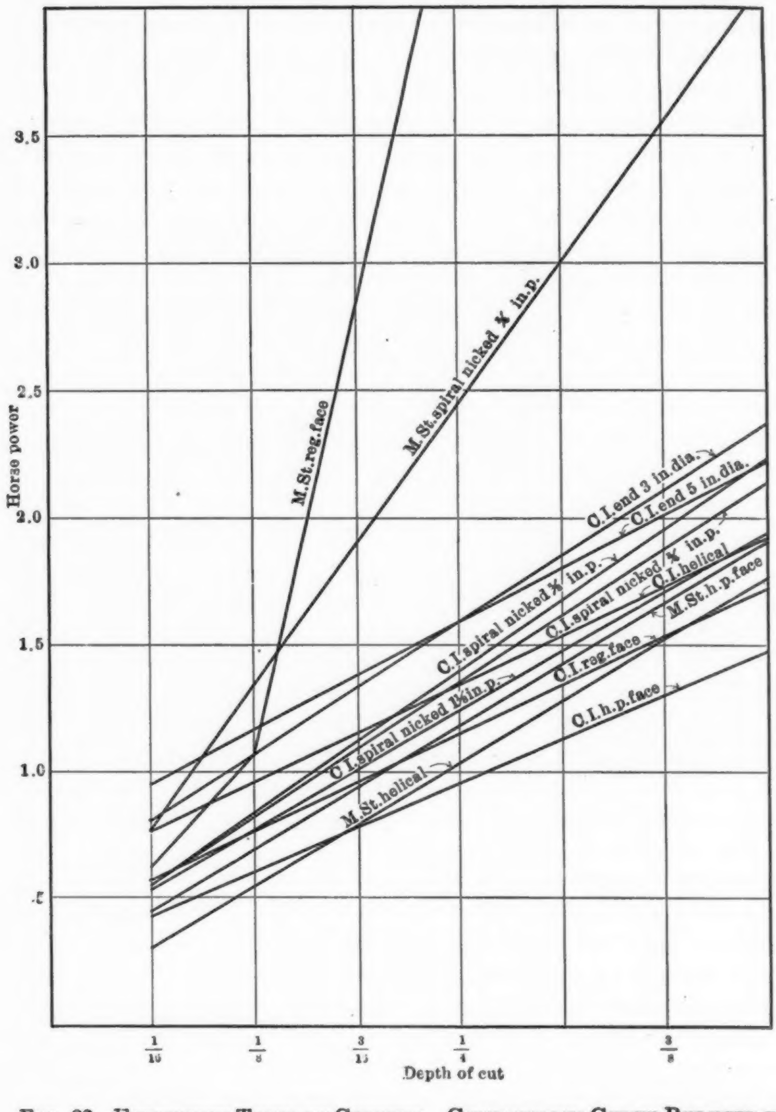


FIG. 22 EFFICIENCY TESTS OF CUTTERS. COMPARISONS CURVE REDUCED TO 1 IN. WIDTH OF CUT. CAST-IRON CURVES CORRECTED FOR HARDNESS OF MATERIAL. FEED 4 IN. PER MIN.

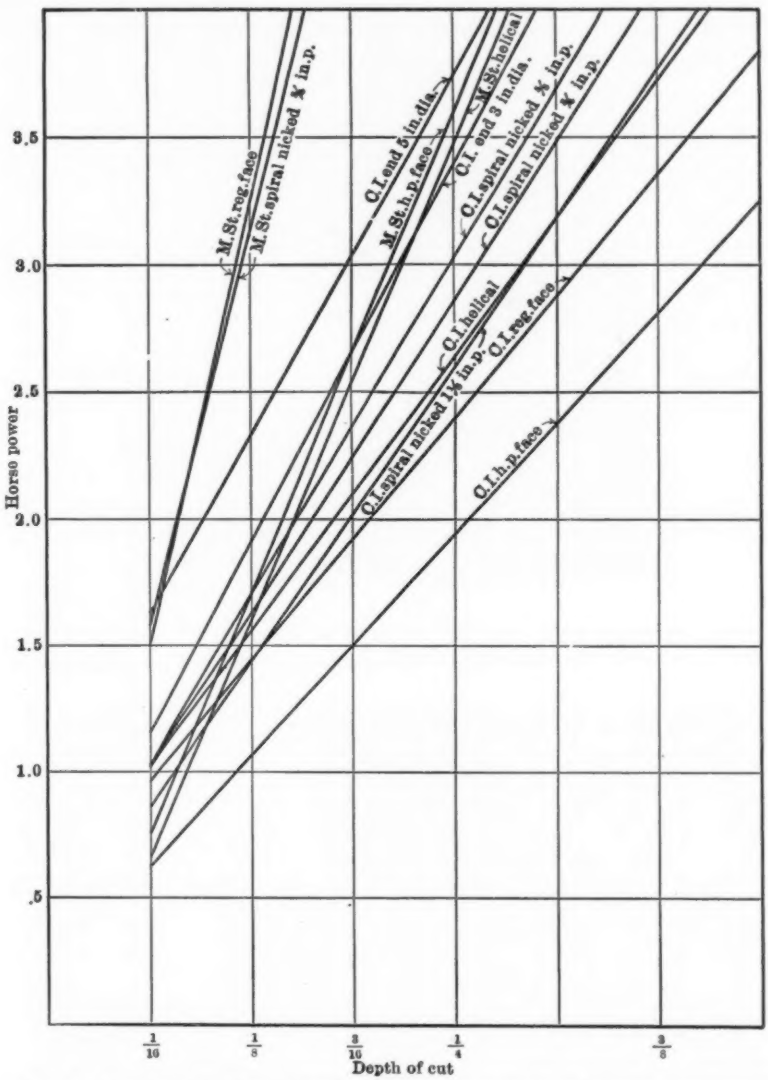


FIG. 23 EFFICIENCY TESTS OF CUTTERS. COMPARISON CURVES REDUCED TO 1 IN. WIDTH OF CUT. CAST-IRON CURVES CORRECTED FOR HARDNESS OF MATERIAL. FEED 14 IN. PER MIN.

49 Fig. 23 gives comparative curves for a feed of 14 in. per min. The order of efficiency is much the same as in Fig. 23 with some exceptions. The helical mill, for instance, becomes more and more efficient as the heavier cuts are taken.

APPENDIX

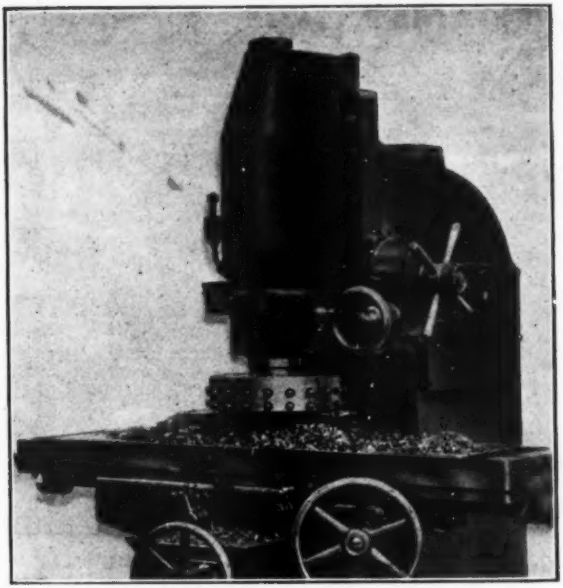


FIG. 24 HIGH-POWER FACE MILL OF EARLY CONSTRUCTION, MILLING MACHINE-STEEL TEST BLOCKS. CHIPS RESEMBLE PLANER CHIPS

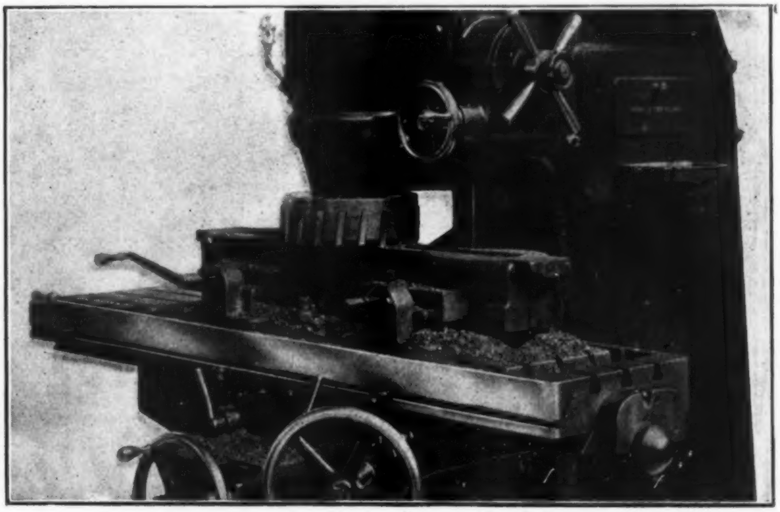


FIG. 25 HIGH-POWER FACE MILL ROUGHING BOTTOMS OF VISE BODIES. ONE PIECE IS CHUCKED WHILE THE OTHER IS MILLING

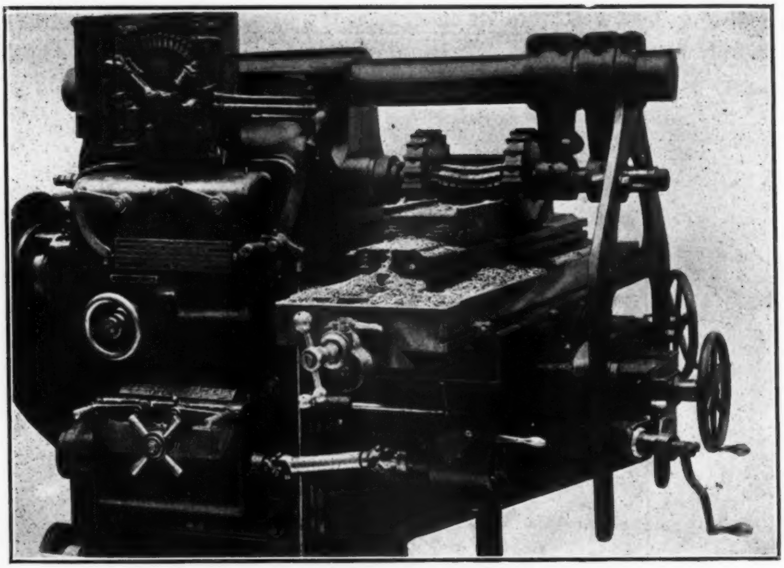


FIG. 26 WIDE-SPACE GANG ROUGHING VISE HOUSINGS

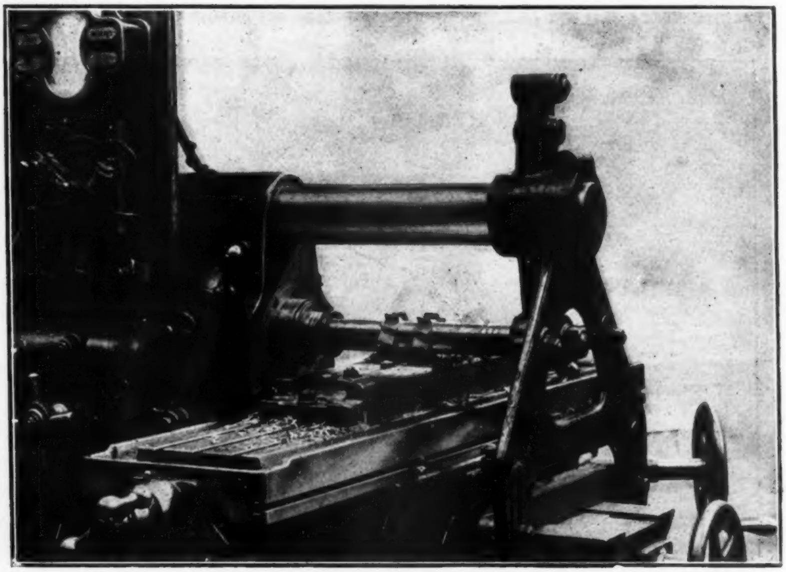


FIG. 27 NEW STYLE GANG AT WORK ON STEEL

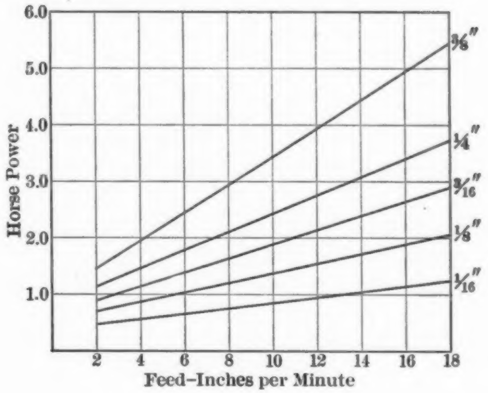


Fig. 28 Efficiency Curves Shown in Fig. 6 Reduced to 1 in. Width of Cut

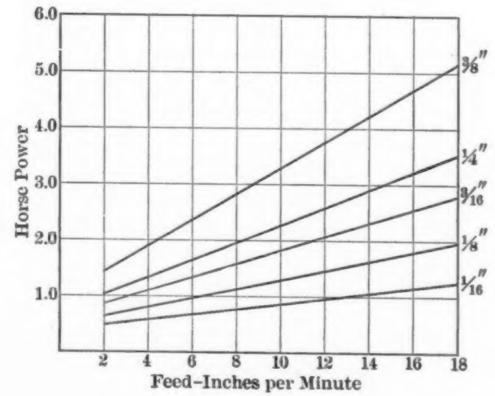


Fig. 29 Efficiency Curves Shown in Fig. 7 Reduced to 1 in. Width of Cut

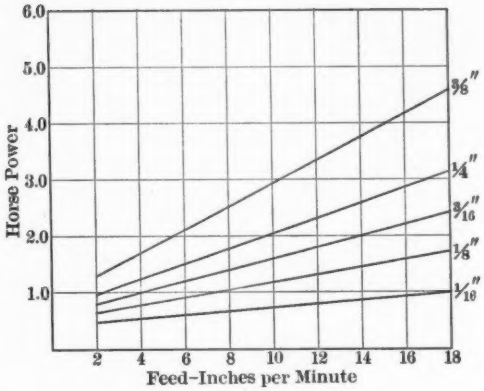


FIG. 30 EFFICIENCY CURVES SHOWN IN FIG. 8 REDUCED TO 1 IN. WIDTH OF CUT

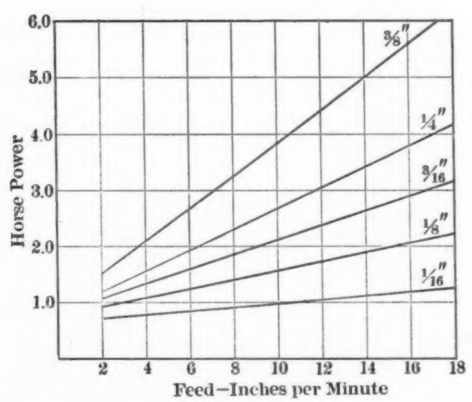


FIG. 31 TESTS OF END MILLING-CUTTER 3 IN. DIAMETER, 14 TEETH. CUTTING CAST IRON, CORRECTED FOR HARDNESS. WIDTH OF CUT 2¾ IN. REDUCED TO BASIS OF 1 IN.

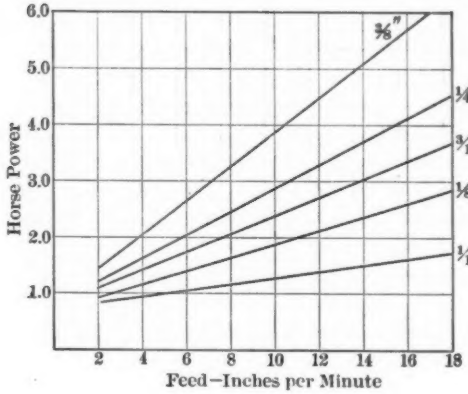


FIG. 32 TESTS OF END MILLING-CUTTER 5 IN. DIAMETER, 20 TEETH. CUTTING CAST IRON, CORRECTED FOR HARDNESS. WIDTH OF CUT 3 IN., REDUCED TO BASIS OF 1 IN.

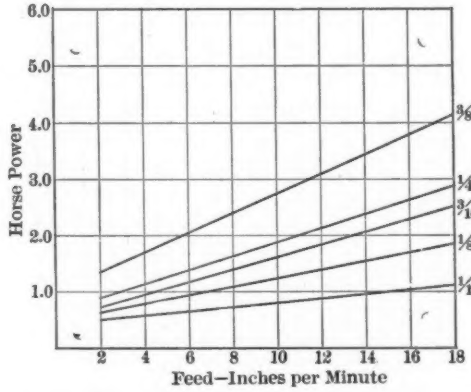


FIG. 33 TESTS OF REGULAR FACE MILLING-CUTTER 9½ IN. DIAMETER, 22 TEETH. CUTTING CAST IRON, CORRECTED FOR HARDNESS. WIDTH OF CUT 6 IN., REDUCED TO BASIS OF 1 IN.

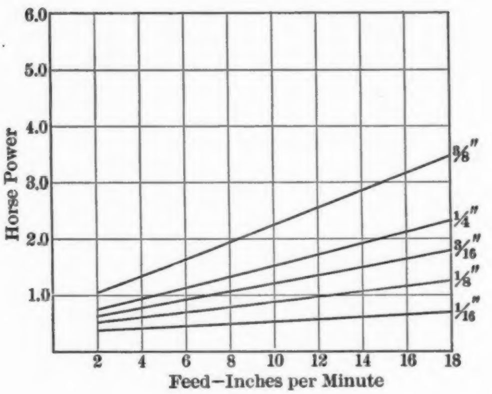


FIG. 34 TESTS OF HIGH-POWER FACE MILLING-CUTTER 8 IN. DIAMETER, 6 IN. TEETH. CUTTING CAST IRON, CORRECTED FOR HARDNESS. WIDTH OF CUT 12 IN. REDUCED TO BASIS OF 1 IN.

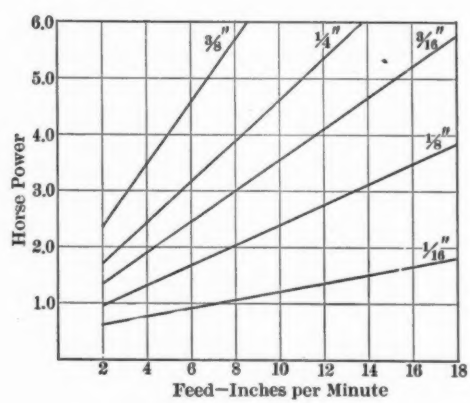


FIG. 35 TESTS OF SPIRAL NICKED MILLING CUTTER $3\frac{1}{2}$ IN. DIAMETER, 14 TEETH, AND ABOUT $\frac{3}{4}$ IN. PITCH. CUTTING MACHINE STEEL: 0.50 MANGANESE, 0.20 CARBON, 55,000 LB. TENSILE STRENGTH. WIDTH OF CUT 6 IN., REDUCED TO BASIS OF 1 IN.

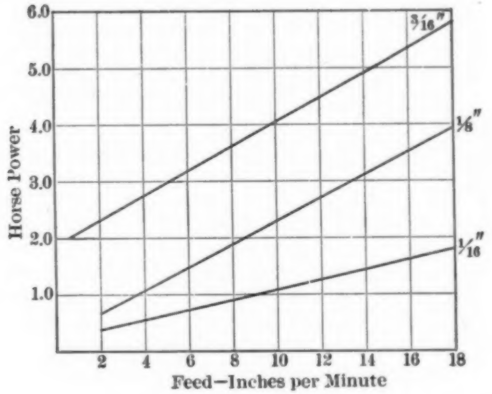


FIG. 36 TESTS OF REGULAR FACE MILLING-CUTTER 9½ IN. DIAMETER, 22 TEETH. CUTTING MACHINE STEEL; 0.50 MANGANESE, 0.20 CARBON, 55,000 LB. TENSILE STRENGTH. WIDTH OF CUT 6 IN., REDUCED TO BASIS OF 1 IN.

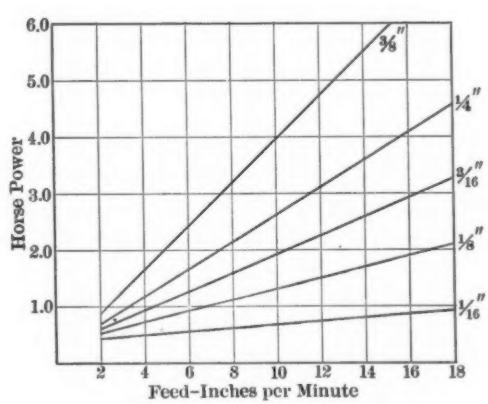


FIG. 37 TESTS OF HIGH-POWER FACE MILLING-CUTTER 8 IN. DIAMETER, 12 TEETH. CUTTING MACHINE STEEL: 0.50 MANGANESE, 0.20 CARBON, 55,000 LB. TENSILE STRENGTH. WIDTH OF CUT 6 IN., REDUCED TO BASIS OF 1 IN.

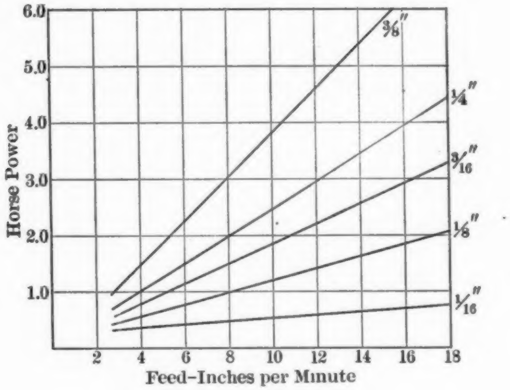


FIG. 38 TESTS OF HELICAL MILLING-CUTTER 3½ IN. DIAMETER, 4¼ IN. LEAD, 2¼ IN. PITCH. CUTTING MACHINE STEEL: 0.50 MANGANESE, 0.20 CARBON, 55,000 LB. TENSILE STRENGTH. WIDTH OF CUT 5½ IN., REDUCED TO BASIS OF 1 IN.

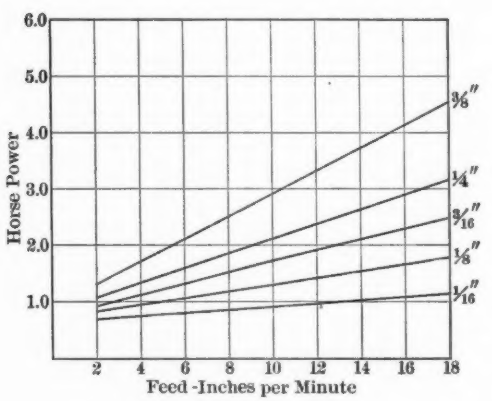


FIG. 39 TESTS OF HELICAL MILLING-CUTTER $3\frac{7}{16}$ IN. DIAMETER, 4¼ IN. LEAD, $\frac{15}{16}$ IN. PITCH. CUTTING CAST IRON, CORRECTED FOR HARDNESS. WIDTH OF CUT 6 IN., REDUCED TO BASIS OF 1 IN.

THE ROTARY KILN

By Ellis Soper, Published in The Journal for October 1910

ABSTRACT OF PAPER

The paper gives a brief history of the development of the rotary kiln and commercially successful applications of it. A drawing is shown of a typical installation of an 8 ft. by 125 ft. kiln for burning cement by the dry process. The temperature curves are for a 7 ft. by 100 ft. kiln and there are three curves showing chemical changes in kilns of various sizes. There is also a table of kiln sizes, outputs and fuel consumptions with relation of the diameter to the length and the actual results from lengthening a 6 ft. by 60 ft. kiln. The heat balance, calculation of mixture, etc., is given for an 8 ft. by 125 ft. kiln operating upon lime rock and shale, using the dry process; also curves showing stresses in shell due to the improper spacing of tires, the fallacy of supporting upon more than two tires and the proper spacing of tires when the weakening effect of heat is considered. A fuel consumption curve illustrating the law of pivotal points, size of kiln conditions remaining constant, and output in barrels per day at which the fuel consumption is a minimum are stated.

DISCUSSION

Richard K. Meade.[1] Mr. Soper in Par. 3 of his paper states that pulverized coal was first tried as a fuel at the Atlas mill. I believe that this is a very much mooted question; one indeed, which even the courts have been asked to decide and which to date has never been settled.

Mr. Edison certainly deserves great credit and also the commendation of cement manufacturers for his courage and ingenuity in building the long cement kiln. The writer was with Mr. Edison at the time these kilns were installed and had many arguments with others in the cement industry as to their practicability. The contentions of all manufacturers at that time seemed to be that these

[1] Meade Testing Laboratories, Allentown, Pa.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

long kilns would overburn the cement and that the resulting product would be lacking, if indeed not entirely deficient, in hydraulic properties. The writer undertook to disprove this and succeeded in doing so by fusing portland cement in an electric furnace. The resulting clinker was found to have excellent hydraulic properties and to compare favorably with the product of the shorter 60-ft. kiln, then universally employed. As a matter of fact, when the long kilns were started, they burned clinker which was in every way similar to that burned by the short 60-ft. kilns and in no way different from it in point of vitrification, appearance or hydraulic properties.

Three variables enter into the production of portland cement clinker; namely, the temperature of burning, length of time in the kiln and the degree of fineness to which the raw materials have been reduced. This may be expressed mathematically as an equation: $A + B + C = D$, in which A represents time, B temperature, C fineness and D a constant, namely, clinker. If any one of the three variables, A, B or C is increased, one or both of the other two will be decreased. By increasing the time in the kiln, the temperature necessary to clinker is decreased, while if the materials are ground more finely, either the temperature or the length of time in the kiln is decreased, and thus the output of the kiln may be increased and the fuel required per barrel decreased. With a long kiln the time in the kiln is simply increased, and I believe our long kilns are all working at a lower temperature than the old 60-ft. kilns employed. Measurements of the temperature of both show that the long kilns work at a lower temperature. The time of the material in the kiln may be shortened or lengthened by the speed at which the kiln is revolved. The long kilns may generally be considered to revolve at a more rapid speed than the shorter ones. The inclination of the kiln from the horizontal has also much to do with the time of the material in the kiln.

Mr. Soper brings up one very interesting point for discussion, namely, whether it is better to install one large kiln having a capacity of say 2000 bbl. per day or four smaller kilns which would produce the same output. A kiln with this very large capacity is of course an experiment, and has been tried only at one large plant in this country where several kilns are employed. The size of the kiln to be installed would seem to the writer, so far as its diameter and capacity are concerned, to depend upon the total production of the contemplated plant and in no plant should a kiln having a capacity larger than 25 per cent of the total capacity of the plant be installed, for the reason that when

the kiln is shut down the whole plant must be shut down. When this occurs, fixed charges go on and the cost of production is consequently increased. One point that all cement engineers are striving for is to design a plant in which shut-downs will be reduced to a minimum, or at least confined to only a small part of the plant. Shut-downs occur often with the large kilns and it is questioned whether the large units save fuel, or at least save enough to make up for the curtailment of production due to the shutting down of a large part of the plant.

One objection to kilns of very large diameter is the key of the brick. If the diameter of the kiln is much above 9 ft., the key of the brick is so slight that constant trouble with the lining will be encountered, unless this latter is of unusual thickness, which of course greatly decreases the working diameter of the kiln. This difficulty, we understand, has been encountered with the 12-ft. kiln employed at present.

We believe that it would not be a good policy for any new company to install kilns with a capacity of more than 25 per cent of the contemplated output. Concerns, however, which have a large capacity can afford to install for experimental purposes a large kiln of considerably greater proportions than that ordinarily used, but so far a greater economy has been obtained by increasing the length of the kiln.

At the plant of the Allentown Portland Cement Company, one of the most modern cement mills, there are installed today four kilns which have a capacity of from 600 bbl. to 700 bbl. daily. These kilns are 8 ft. in diameter and 120 ft. long. The coal consumption is on an average 80 lb. per bbl. of cement produced. The capacity of these kilns, however, owes some of its increase over other kilns of the same or even greater size to the fact that both the raw materials and the coal used for burning the latter are pulverized very finely. As already stated, this affects the capacity and the economy of the kiln.

In general it may be stated that the capacity of the kiln is dependent on its diameter, and its economy, so far as fuel is concerned, on its length. That is, if we wish a kiln with a large output merely we would increase the diameter, while if we wish a kiln to be economical we would increase its length. That is, a kiln 6 ft. by 100 ft. will burn cement with less coal than will one 6 ft. by 60 ft. On the other hand, a kiln 7 ft. by 100 ft. will give a greater output than will one 6 ft. by 100 ft. In figuring the output of a kiln the thickness of the lining must always be considered, for a kiln 8 ft. 6 in. in diameter

lined with 9-in. brick will have the same internal diameter and give as much clinker as one 9 ft. in diameter lined with 12-in. bricks.

Kilns 8 ft. by 125 ft. are in operation today at the Great Western Portland Cement Company's plant, which under normal capacity, average from 800 bbl. to 850 bbl. daily. Oil, however, is used as fuel.

In Par. 8, Mr. Soper states that the kilns are lined with magnesia brick. At present the use of this brick is uncommon in the east, where a highly refractory silica brick is almost universally employed. In certain parts of the country a bauxite or alumina brick is employed and at one or two plants bricks made from portland cement clinker and cement are used.

Mr. Soper gives a number of interesting charts, among them two showing the chemical changes in a 6 ft. by 60 ft. and in a 6 ft. by 160 ft. rotary kiln respectively. A comparison of these two charts shows very conclusively the functions performed by the additional length of the kiln. If the dips in the lines of the various compounds are taken out, as they should be, since these dips are due to unavoidable analytical and experimental errors, and the lines are plotted to smooth curves, it will be seen that in the long kilns practically no change takes place for the first 80 ft. other than the driving off of the water. Up to this point practically all of the heat taken up by the materials has been employed in heating them up to the temperature at which dissociation of the carbon dioxide begins (about 1800 deg. fahr.). From this point to 130 ft. from the entrance of the kiln all the heat absorbed by the material is utilized for two purposes, viz: for the dissociation of the carbon dioxide and to heat the material to a temperature necessary to clinker (about 2200 deg. to 2500 deg. fahr.), while in the last 20 ft. of the kiln the clinkering itself takes place. This is supposed to require no heat and to take place as soon as the critical temperature of combination is reached. It is supposed and has been seemingly experimentally demonstrated that heat is given off in clinkering. With the long 160-ft. kiln, therefore, it will be seen that over half the kiln is utilized to heat the material to the point at which dissociation of the carbon dioxide begins, while with the short 60-ft. kiln only about one-quarter or 16 ft. of the length is so used. Consequently, these 16 ft. must be very much hotter in order to do the work of the 90 ft. in the longer kiln, and the gases must therefore leave the kiln at a much higher temperature. The function of the extra length therefore is to use the heat of the gases to warm the incoming material.

Mr. Soper gives an interesting mathematical discussion of the utilization of the heat in the rotary kiln. These heat balances are dependent on so much experimental data which have not been fully established that the writer has never put very much credit in them, although he has very frequently drawn them up himself. Professor Landis of Lehigh University has made a number of these heat balances for various sizes of kilns and it is interesting to compare his results with those obtained by Mr. Soper. A discusssion of the various points brought out by these balances would require a great deal of time, but it may be interesting here to note that Professor Landis believes this heat to be distributed under the best conditions something as follows:

For chemical reactions, such as the decomposition of the carbonates, etc.	24.8 per cent
For the chimney loss with perfect combustion and waste gases at 500 deg. cent	21.4 per cent
Clinker loss, that is, heat carried off by clinker	16.6 per cent
Radiation and conduction loss with ordinary lining	37.2 per cent

It will be seen by examining the balances of Mr. Soper and Professor Landis that a large percentage of heat is carried off through the kiln walls and hood by radiation and conduction. It has been proposed to stop this loss by suitable linings, which are poor conductors of heat. One point, however, that must be considered in this connection is that it is necessary to carry the heat away from the lining in order to keep it cool. The principle is exactly the same as the employment of water-cooled bosh plates in a furnace blast. If all the heat were confined to the kiln and the fire brick linings of the latter were not cooled, the bricks in the clinkering zone would be rapidly corroded and eaten away by the strongly basic material burned in the kiln. It is possible, however, that by the substitution of some other form of brick than the ordinary silica brick this could be avoided.

W. S. Landis.[1] Measurements made by myself on the temperature of discharged clinker have shown temperatures of 1830 deg. to 2000 deg. fahr. In no cases have I ever seen temperatures as low as Mr. Soper's, except in the case of an under-cooler being used in connection with the kiln.

Waste gases passing into the stack at 650 deg. fahr. is almost good boiler practice. The lowest temperature I have ever recorded in our

[1]Associate Professor of Metallurgy, Lehigh University, South Bethlehem, Pa.

own country is 900 deg. fahr. and temperatures above 950 deg. are quite common. Abroad, even under the most excellent supervision the stack temperatures in kilns of the size studied by Mr. Soper have been above 950 deg.

In nearly all kilns the draft is regulated by the opening and closing of a door in the base of the stack. It is barely possible that the temperature given was measured in the stack after dilution of the kiln gases with a large amount of cold air through such a door. In that case correction should be made according to the quantity of gases passing out through the stack for this extra air entering it.

The temperature at which CO_2 is liberated from the carbonates in the mix is not 1000 deg. fahr. With only 10 per cent CO_2 in the gases passing over the mix, corresponding to a CO_2 tension of 76 mm. mercury, the equilibrium temperature would be 1200 deg. fahr., and to insure rapid decomposition under operating conditions the temperature must be considerably above that given. Measured values for this temperature made in a running kiln have shown temperatures nearer 1470 deg. fahr.

The heats of combination of CaO, Al_2O_3 and SiO_2 as given in the paper are new to me. If we knew the exact natures of the chemical reactions taking place in the kiln we might use appropriate figures for this calculation, but I do not think this is known. By clinkering the mix used in the Nazareth region in a bomb calorimeter I have evaluated a heat of formation of the clinker (union of CaO, Al_2O_3 and SiO_2) of 360 B.t.u. per lb. of clinker formed, a figure much less than that used by the author. I have further verified my figure by the rise in temperature noted in a very careful study of the operation of a rotary kiln made in Germany and found it to hold within a very few per cent.

In the item of heat carried off by waste gases I note that the author uses as the weight of the waste gases that of the air used in combustion. This is a decided error as these gases contain CO_2 and H_2O, N_2 and excess air, an entirely different material from the air entering the kiln.

In the summary of the heat balance I note another very serious error. In items *b* and *c* the author has calculated the heat put into the mix and clinker. Again in items *d* and *f* he has charged himself with the heat in these same materials; in other words he has charged himself with the heat required to raise them to the required temperature and again with this same heat in them. I was further surprised to see, after this error that he had not somewhere accounted for the heat in the clinker between 1400 and 2500 deg. fahr.

Further I note that the author has charged the heat in the excess air against the calorific power of the coal and again inserted this same heat on the other side of the balance sheet as part of the heat carried out in the waste gases, which are made up of the air used plus this same excess of air.

If the author will remove these twice-counted items from his summary he will not have an unaccounted difference of 16 per cent of the total heat available, particularly if he uses better specific heats and weights of stack gases.

The whole balance sheet could be very much simplified by constructing it as follows:

HEAT AVAILABLE

Sensible heat in mix, coal and moist air used for combustion
Heat of formation of clinker
Heat of combustion of fuel

HEAT DISTRIBUTION

Heat carried out in stack gases
Heat carried out in hot clinker
Heat required to decompose carbonates
Heat lost by incomplete combustion (if existing)
Heat lost by radiation and conduction

I have published a number of balance sheets based on this form in the Cement Record.[1] It is not possible to reconstruct the balance sheet given above along this line without a great deal of trouble, because of lack of sufficient data.

E. A. W. Jeffries. I will not venture to discuss any of the statements made by the author, but will call attention to a point of some importance with reference to the method of firing rotary kilns which Mr. Soper did not discuss. In his opening paragraph the remarkable statement is made that the burning cost represents from one-third to one-half the total cost of manufacture of a barrel of portland cement. In his summary of the heat distribution (Par. 12), Mr. Soper shows that less than 45 per cent of the heat delivered by the fuel does effective work and this figure is undoubtedly above the average found in practice. Part of this loss is unavoidable because there must be some radiation and there must be some heat carried away by the stack. There is no doubt, however, that

[1]Cement Record, Vol. 2, September 1909 and Vol. 3, February 1910.

the large proportionate cost above mentioned can be greatly reduced when cement manufacturers get ready to take up earnestly and intelligently the problem of properly applying producer gas to their business. There have been many abortive attempts, but never to my knowledge a thorough one. One reason for this is that it has been only recently that a really good gas producer adequate for this severe service has been available. Such a producer is now well developed and well tested.

The advantages of this method are: first, in making a large variety of cheaper coals available for this service which will not give satisfactory results in the pulverized state; second, when gas is burned there is no occasion for using a surplus of air, since a temperature sufficiently high can be maintained, without the loss from this source, whereas with pulverized coal at least 50 per cent excess air must be used to insure perfect combustion, which is even then difficult to maintain; third, the running expense for labor, wear and tear is very much less in a good gas plant than in a coal-drying, pulverizing and conveying equipment.

R. C. Carpenter. The paper presented by Mr. Soper is one of great interest to cement engineers. They will all, I am sure, agree with Mr. Soper in respect to the improvements which he mentions as having been produced by the installation of the large kilns in place of the small ones. Engineers who are familiar with the art also realize the truth of the statement which he makes in Par. 3 and in which he states, in effect, that Mr. Edison was laughed at when he installed rotary kilns 9 ft. in diameter by 150 ft. in length. They will also agree with him that the installation of these large kilns, for which we must thank Mr. Edison, is the most important advance step in the history of the industry from the engineering standpoint. It is my opinion from a careful study of the industry that Mr. Edison not only discovered the advantage of employing large kilns, but that he also developed a new principle of operation which applies to such kilns. It is due as much to the application of this principle as it is to the use of large kilns that the great improvements to which Mr. Soper refers have been brought about.

Several statements in the paper seem to be in error, or at least to disagree with my experience and observation. One statement to which I would call attention is the fuel consumption of the 60-ft. kilns. In Par. 11 for instance, the author states that a 6 ft. by 60 ft. kiln has an output of 140 bbl. per day and a fuel consumption

of 240 lb. per bbl. The fuel consumption referred to is, it seems to me, extreme even for such wet materials as were employed when marl and clay were taken as the raw cement materials. For dry materials the consumption is certainly much less. In Table 1 I note that he gives as the coal consumption of normal 60-ft. kilns 6 ft. in diameter, 140 lb. to 160 lb. of coal per bbl. This doubtless refers to the burning of dry material. That fuel consumption, in my opinion, is somewhat large even for that size of kiln. My own experience indicates that the coal consumption of the 6 ft. by 60 ft. kiln averaged perhaps 110 lb. per bbl. with dry material and varied from 125 lb. to something approaching 100 lb. under the most efficient conditions. The output of these kilns was also somewhat greater than stated in the paper, which mentions 175 bbl. per day as the output. My experience indicated that the 6 ft. by 60 ft. kilns sometimes gave an output of 200 bbl. or even 225 bbl. per day under favorable conditions. It may be, however, that Mr. Soper's figures in Par. 11 are fairly comparative and the figures given at the end of the paragraph may be of interest as showing actual comparative results on similar wet materials.

The heat balance which is given in connection with the paper is an interesting one. There is in my opinion, however, quite a serious mistake in calculating the amount of heat carried off by the waste gases. The paper assumes that only 8 lb. of air are theoretically required to burn 1 lb. of coal, whereas about 50 per cent more than that is theoretically required for pure carbon. This will not differ much from what is required for coals containing a considerable amount of volatile matter, as is the case with most coals employed in rotary kiln practice. This error is neutralized to some extent by the assumption that one and one-half times the theoretical air supply is used, although even this assumption does not allow for the considerable percentage of excess air which must be used in rotary kilns. Making this correction in the summary of his results, the losses accounted for by the waste gases will be increased considerably and the calculation made more reasonable.

Another assumption made in the paper which I think is far from the truth, is regarding the temperature of the gases leaving the kiln. This temperature is assumed to be 650 deg. fahr., an amount not greatly in excess of what we find in the stacks of boilers when they are heavily pushed. I have personally measured the temperature at the bottom of the stacks in several instances and have never found it as low as Mr. Soper indicates. My own experience is that if the

kilns are operated at economical capacity the temperature of the kiln gases at the base of the stack will not fall below 1000 deg. I do not believe that a lower stack temperature indicates economical operation, considering the output with reference to the expenditure and overhead charges. If this correction is made to the heat balance it will roughly indicate that the stack losses are about 15 per cent instead of 10 per cent and the radiation losses about 12 per cent instead of 16 per cent, both of which results are somewhat more reasonable than those given. I doubt that under good conditions of operation the stack loss should fall under 30 per cent.

It should be noted that the heat distribution given in the paper is open to some question because it is obtained by calculations made from assumed conditions. Some of the assumed conditions do not seem to be very reasonable; for instance, he assumes that the average temperature of the kiln shell is about 450 deg. fahr. and the average temperature of the surrounding air 70 deg. I have no data as to the temperature of the kiln shell, but I have been in a number of kiln rooms and I never yet had the good fortune to be in one in which the average temperature of the air was as low as 70 deg. It usually is much higher, especially in the neighborhood of the kiln. These various corrections will not, however, greatly change the results.

It may be mentioned that the heat which is stated to be liberated by chemical reaction is due to the heat of combination of the various silicates of the cement clinker. This heat, which is evolved during the clinkering operation, makes up to some extent for the large amount of heat required to calcine the material and drive off the carbon dioxide from the calcium and magnesium carbonates which form such a large proportion of the raw material. The data bearing on these heats of combination are open to some question, especially in view of the doubt as to the exact chemical compounds present in the clinker material. I may add that some of the other data contained in this paper do not seem to conform to regular cement practice. I am not, however, sufficiently informed as to the conditions under which these results were secured to make a detailed discussion of them.

H. E. Brown. I heartily agree with Professor Landis in reference to the heat generated by the action of the silicates of lime and alumina in rotary kilns. Le Chetelier[1] has done a great deal of work along these lines, and it is easy to determine from his work that in 1 lb. of cement clinker there is only about 170 B.t.u. generated.

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[1]Revue de Metallurgy, October 1905.

In Par. 9 of Mr. Soper's paper, he states that the temperatures of the material were calculated by means of these data. It would be interesting to know how Mr. Soper can calculate the temperature of material from the data given, since there exists no accepted formulae or relation between heats of the gases and heats of the materials.

In the analysis shown in Fig. 5, the curve for CaO at Station 3 shows 68 per cent and then drops at the mouth of the kiln to 66.5 per cent. Such a variation runs counter to common practice, and throws a doubt upon the accuracy of the investigation.

In Fig. 2, under the diagram, he states: "Curve—2—Maximum Temperatures of Materials Calculated from Gas Temperatures. Temperature at Stations *B*, 1, 12 Actually Observed." He claims to have calculated the curve from the feed end of the kiln up to Station 1, but it is quite impossible to draw such a curve from any data of which I have knowledge.

Again, in Fig. 3, Mr. Soper has shown a cement containing 15 per cent of R_2O_3; and in Fig. 5 a cement with 66.5 per cent of CaO. These are such unusual portland cements that one is forced to question the accuracy of the analytical work. It would also add to the value of the paper if Mr. Soper would give in detail his method or formula for deriving the curves shown in Figs. 6 and 7.

W. B. Ruggles. In Fig. 7 Mr. Soper has shown the stress diagrams for the kiln in which there are three tires. The weight in the lower diagram is on the kiln's outer tires, the center tire not touching at the rollers. It is possible, on account of the warping effect of the heat in the kiln at certain intensities, that the whole weight of the kiln wlll rest on the center tire, in which case the stresses will be nearly double what the middle stress is on this diagram.

The Author. Referring to Par. 3 of my paper, perhaps I did not make myself quite clear regarding the use of pulverized coal. Fuel in this form had been used for other purposes than burning cement several years prior to 1895. It had also been used for burning cement previous to this date in Europe. What I meant to imply was that the Atlas was the first company in the United States successfully to adopt and maintain its use in the burning of portland cement clinker.

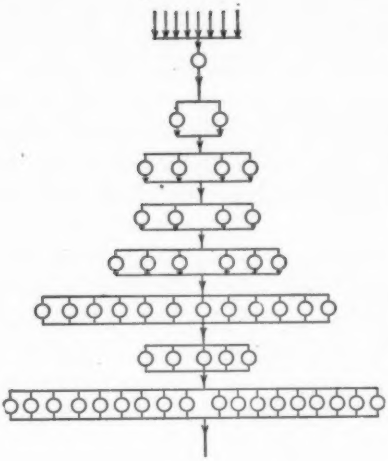
It might be interesting to compare or rather to contrast two mills, of say 2000 bbl. daily production, one built ten years ago (Fig. 10), and the other built last year (Fig. 11). Assuming both mills to be operat-

ing on the same materials and under similar conditions, the flow-sheet of the mills would be about as shown in Fig. 10 and 11, omitting the smaller details such as conveyors, elevators (represented by arrows), proportioning apparatus, bins, separators, feeders, etc. I have shown both systems of grinding, the two stage, or ball and tube, and the single stage, or Griffin or Fuller installations. I have omitted the fuel mill and the shale or clay departments, also the power plant. The growth here has been as marked, but the above examples will serve to illustrate in a general way the enormous advance that has been made in practically every step in the manufacture of portland cement. The main idea throughout this growth and development has been *simplicity*, *economy of operation* as to labor, supplies, etc., and a corresponding reduction in the cost of production.

Until the year 1907 the largest gyratory crusher built weighed 200,000 lb. It was called a No. 10, and was capable of receiving a 24-in. cube of rock. The Hunt Engineering Company of Kansas, with whom the writer was associated at that time, installed in a mill in the South a No. 18 gyratory, weighing 426,000 lb. and capable of receiving a 36-in. cube of rock. This single step, by reason of a reduction in labor through the use of a large steam shovel for loading the rock direct from the blast and a very appreciable decrease thereby in explosives, reduced the cost of production about $0.07 per bbl.

In crediting Mr. Edison with the biggest single advance in the industry, I referred more particularly to the burning department, since the saving of 40 lb. to 50 lb. of coal by his kiln over the 100-ft. kiln which was then in use in the American mills, effected an approximate saving of $0.04 to $0.05 per bbl. His "step" was no greater proportionately than that made by the fellow who increased his kiln from 20 ft. to 40 ft. and later from 40 ft. to 60 ft., but it came at a time when the business was assuming an important position in the commercial growth of the country, and Mr. Edison's already well-earned reputation for doing big things was as responsible for the coupling of his name with this improvement as the importance of the improvement itself.

The design and construction of the particular kiln employed by Mr. Edison would be adopted by few engineers or manufacturers because of the difficulty of keeping in alignment the carrying rolls and because of the extreme weight and cost, the shell being made up of cast-iron flanged sections 5 ft. in length, and each flange joint being machined and utilized as a tire. Mr. Ruggles' statement that the whole weight might



Laborers in quarries

No. 8 Gyratory Crusher, Weight 100,000 lb.

Two No. 4 Gyratory Crushers

Four 4 ft. by 30 ft. Rotary Dryers

Four No. 6 Ball Mills

Twenty 4 ft. by 16 ft. Tube Mills

Eleven 6 ft. by 60 ft. Rotary Kilns.

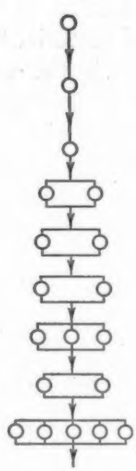
Five 4 ft. by 35 ft. Rotary Coolers

Eighteen 30-in. Griffin Mills (33-in. Fuller Mills not in use at this time)

FIG. 10 FLOW-SHEET OF PLANT BUILT IN 1900

Production of Country 8,482,000 bbl.

Cost of production per barrel, assuming coal at $2 per ton, was $1.00.



100-ton Steam Shovel (displaces 100 men)

One No. 22 Gyratory Crusher, Weight 600,000 lb.

One No. 6 Gyratory Crusher

Two 6 ft. by 60 ft. Rotary Dryers

Two 7 ft. by 7 ft. Ball Mills

Two 8 ft. by 26 ft. Tube Mills

Three 8 ft. 6 in. by 125 ft. Rotary Kilns

Two 6 ft. by 60 ft. Rotary Coolers

Five 54 in. Griffin Mills or Fuller Mills

FIG. 11 FLOW-SHEET OF PLANT BUILT IN 1910

Production of Country 74,000,000 bbl.

Cost of production per barrel, assuming coal at $2 per ton, was $0.60.

be carried on the center tire (Fig. 7) is difficult to imagine, as the kiln would not balance at this point, and either of the outer tires would touch, resulting in an extreme stress at the center tire, due to the increased overhang. Any two adjacent tires and the two outer tires can touch, but the case would be extremely rare when the whole weight is carried on the center tire. In this event there would unquestionably be an immediate failure through tearing of the sheets or shearing of the rivets or buckling.

I believe Mr. Meade is correct in stating that in no plant should a kiln having a capacity greater than 25 per cent of the total capacity of the plant be installed, assuming of course, the kilns to be of the same size, though the statement might be qualified to admit a kiln of 30 to 33 per cent of the capacity of the mill.

In Mr. Meade's equation of time plus temperature plus fineness equals clinker, (a constant), it would appear there were more variable elements than he gives. If the quantity of air blown into the kiln is varied, the fuel consumption and the output are affected. The amount of material or load in the kiln has a direct bearing on the fuel consumption per barrel, and the size of the load is affected by the incline or pitch of the kiln. This question of kiln capacities and fuel consumption brings us back to the admitted fact that *less fuel per barrel* is required in burning the so-called Lehigh or cement rock, which requires but 5 to 15 per cent additional material for correction and is *already intimately mixed by nature*, than in the case of two *independent materials* as lime rock and shale. The finer grinding of the raw materials admits of more intimate mixing and a cement rock ground to a fineness of 94 per cent through 100 mesh should not require more fuel in the kilns than two independent materials ground 98 per cent through 100 mesh, though the power consumed is greater in the second instance.

While fine grinding assists clinkering and reduces fuel consumption, I question whether the clinkering temperature is not correspondingly decreased. A finely ground material must pass through the kiln faster than a more coarsely ground product, assuming the coal burned per minute to be constant, but, taking the case of a raw-material dryer, which requires a certain number of pounds of coal per ton to dry rock crushed to 1½ in. and under, and considerably less coal per ton to dry rock crushed to ¾ in. and under. It does not necessarily follow that the moisture in the rock is evaporated at a temperature less than 212 deg. fahr.

The variation of the silica and iron contents may vary the fuel con-

sumption and production, and the *personal equation* is an exceedingly important factor to be considered. I assume, however, that Mr. Meade intended these to be constant during the application of his formula.

As Mr. Meade so clearly states, all conditions remaining the same, *increasing the length decreases the fuel consumption,* though there are limiting lengths for each different diameter beyond which the fuel consumption increases. *Increasing the net diameter increases the production,* though there is a slight increase in production when the length is increased and a decrease in fuel consumption as the diameter is increased. The speeds of the larger kilns, so far as we have observed, are much slower than the small ones. A 6 ft. by 60 ft. kiln generally makes one revolution in 60 to 90 seconds while an 8 ft. by 125 ft. kiln requires from 2 to 4 minutes.

The heat balances at present must be based to so great an extent upon assumed conditions and experimental data, that their value is approximate and useful only for comparison purposes, though it is quite possible to determine fairly accurately several of the percentages of heat distribution. One of the important losses is by radiation. Mr. Edison overcomes this quite successfully by introducing a layer of ½-in. asbestos between the brick lining and the shell. The expense of this method however, is quite prohibitive.

Professor Landis' criticism of the temperature of the stack gases is correct as regards the dry process, but the conditions in the example were taken from ordinary practice. The stack temperature should be nearer 1000 deg. fahr., although we have noted instances where the temperature is less than this.

Different authorities gave varying figures for the heats of combination and decomposition. The amounts must necessarily be approximate and determined by experiment. The temperature at which CO_2 is driven off, I understand, is questioned. I believe that when this action is taking place the materials are not of the same temperature as the passing gases which, as observed in one instance, was approxinately 1600 deg. fahr.

Mr. Jeffries has brought up a subject which should receive very serious consideration from the manufacturer and the engineer. The gas producer has only lately been developed in sufficiently large units as to admit of its application to a modern cement kiln. There is one disturbing feature, however, that will have to be considered and experimented upon. In burning cement clinker with natural gas, approximately 2000 cu. ft. per bbl. are required. This gas con-

tains about 1000 B.t.u. per cu. ft. Ordinary producer gas contains less than 200 B.t.u. per cu. ft. When natural gas was first tried in Kansas, no air was used or mixed with the gas and the result was discouraging. A mixer or burner was finally evolved and different percentages of air necessary for the combustion of the gas were mixed and blown in with the gas. This amount of air has been steadily increased, the productions correspondingly increased and the fuel consumption decreased. If producer gas acts similarly to natural gas, there is some work to do to perfect the system, but it can be done and should eventually solve the fuel question by reducing the consumption approximately to that of the old stationary or vertical kilns.

Referring to Professor Carpenter's question regarding the output and fuel consumption of the 6 ft. by 60 ft. kiln in Par. 11, the figures are accurate, but this kiln was operating on wet materials and hence the low production and high fuel consumption.

I believe I have covered Professor Carpenter's opening remarks in the first part of my closure. However, his statement that Mr. Edison has developed a new principle of operation in connection with the long kiln is not quite clear to me; the same changes occur in the small kiln as in the large one and disregarding the drying feature, the changes take place relatively proportional to the length of the kiln.

I am very glad indeed to correct the obvious errors in the heat balance, though the final results are not greatly altered.

Replying to Mr. Brown, the temperatures of the gases were *actually observed*. The temperatures of the materials were calculated, considering those observed at Stations 1, 2 and 11 as follows: The temperature of the raw feed entering the kiln was 95 deg.; the stack gases (wet process), 456 deg.; approximately 33 ft. down the kiln from the feed end all the moisture had disappeared. It is assumed that the material was heated to 212 deg., remained fairly constant while the water was evaporated, and gradually rose in temperature to 1000 deg., remaining at that temperature while the gases were liberated. The material was then gradually heated to clinkering temperature and remained constant until this action was completed and then cooled to the temperature of the discharged clinker which was observed. In making tests of this kind there is always the possibility of an error in the analytical work or in the calculations, but I doubt if there are any materials which when spread out over a surface 160 ft. long will conform to within 1 or 2 per cent of an assumed theoretically perfect case. There are very few cements on the market which conform closely to an *ideal* cement so far as chemical analyses are concerned.

I know of one which has contained as high as 10 to 12 per cent magnesia, but it apparently passed all the physical tests required of it. The formulae for the moment diagrams, etc., are simple mathematical equations found in most higher text books. The method of treating the weakening effect of the heat is based upon experiments and the use of a large factor of safety.

In the original calculations and the revision, the sensible heat in the raw mix and the coal was disregarded. Assuming the temperature of the stack gases to be 1000 deg. fahr., item *f* Par. 12 becomes

$$208.8\ (1000-70) \times 0.24 = 46{,}604 \text{ B.t.u.}$$

and using 18 lb. of gas for 1 lb. of coal as the products of combustion, and assuming an air supply twice that theoretically required, *g* Par. 12 becomes

$$90 \times 18 = 1620 \text{ lb. gases (waste) per bbl.}$$

$$1620\ (1000-70) \times 0.23 = 338{,}418 \text{ B.t.u.}$$

a, under Heat Delivered to Kiln, Par. 12, becomes

$$4(1000-70) \times 0.24 = 923 \text{ B.t.u.}$$

$$12421-923 = 11{,}498 \text{ B.t.u. available}$$

then

$$90 \times 11{,}498 = 1{,}034{,}820 \text{ B.t.u. total available heat of combustion}$$

The summary in Par. 12 can then be written:

Heat distribution in kiln

	B.t.u. per bbl.	Per Cent
a Dissociation of carbonates	357,000	27.6
b Heating 600 lb. dry raw mix from 60 deg. to 1000 deg. fahr.	112,800	8.6
c Heating 380 lb. raw mix from 1000 deg. to 2500 deg. fahr.	136,800	10.5
e Radiation from shell and hood	224,270	17.7
g Carried off by waste gases	338,418	26.2
Total	1,169,288	
Received by kiln	1,292,208	
Unaccounted difference (probably radiation)	122,920	9.5
Total		100.1

Heat received by kiln

	B.t.u. per bbl.	Per Cent
a Combustion of coal...............	1,034,820	80
c Liberated by chemical reactions....	247,662	19.1
d Delivered through air pipe.........	9,750	0.9
Total available heat................	1,292,208	100

b becomes 0 since gases escape to stack at about the same temperature at which they are liberated.

The losses are

d Heat discharged with clinker.......	118,500
e Radiation......................	224,270
f Carried off by gases...............	46,604
g Carried off by waste gases (products of combustion and excess air)....	338,418
under heat distribution in kiln	

A GRAPHICAL METHOD OF CALCULATING STRESSES IN A CONNECTING ROD

By W. H. Herschel, Published in The Journal for October 1910

ABSTRACT OF PAPER

To avoid the assumptions generally made in calculating stresses in a connecting rod by analytical formulae, a graphical method is proposed for finding the stress at any point of a rod of any shape. Determination of the inertia forces of material points is simplified by means of a diagram calculated from exact formulae. The bending moment due to inertia forces is calculated by the usual string polygon method, and there is also a moment equal to the axial method and a moment equal to the axial thrust multiplied by the sum of the deflection and an assumed eccentricity of loading. Deflections are found by Mohr's method and the eccentricity is assumed in accordance with the conclusions of Moncrieff.

The numerical examples show that in a simple shaft of uniform stress the maximum bending moment and maximum diameter will be less than 0.6 the length of the rod from the crosshead end, and the maximum bending moment at any one point will occur at about 38 per cent stroke. The stresses are much greater than given by the usual formulae, mainly on account of considering the bending moment due to axial thrust.

DISCUSSION

L. L. Willard. Mr. Herschel's paper is of interest as a graphical method of finding stresses in a connecting rod, and as far as reference to many formulae and methods goes. Something more valuable to engine designers, however, is a method of calculation which can be applied with little labor. With keen competition, such as has been experienced in the past few years, the engineering departments of manufacturing concerns are very seldom given time to investigate many interesting subjects which are not considered necessary.

Any successful builder of steam or gas engines must standardize as far as possible the parts which go to make up the engine, in order to reduce the cost of manufacturing. In steam engines, various steam

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The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

pressures are encountered, as in gas engines, due to the various compositions of gases. The maximum conditions from which the rods are designed are, therefore, taken. Many builders use the same rod for more than one size of cylinder, as long as the total pressure and revolutions per minute do not exceed the value for which the rod is designed.

It is true that the method devised by the writer and referred to in Mr. Herschel's paper (Pars. 8 and 25) is based on certain assumptions, but the value of e in Mr. Herschel's formula, which allows for the lack of homogeneity of material and eccentricity of loading is also apparently assumed. This value for homogeneity can probably be obtained for a line of connecting rods only by experiment or be based on known behavior of rods of similar design used in the past and then set at a maximum value.

It thus appears that while the usual assumptions are eliminated, as stated in the paper, others are necessary, so that judgment is still required in the selection of certain values about which no more is known than what is covered by the usual factor of safety allowed, taking care of inaccuracies in making diagrams, calculations and minor assumptions. The graphical method proposed is also much more complicated, the chances of error being increased thereby, and requiring a great deal more labor than usual. The results given seem to be no better for practical use than those obtained by shorter methods.

Gaetano Lanza. I have not yet published anything in regard to computing the stresses in rods. An article was published by George Goodell several years ago which was based on some work I had been doing, as he says in the paper. Since then I have figured, or had figured by students under my direction, the stresses in a number of rods. The discussion by Mr. Goodell can be very much simplified, so that the analytical determination of the stresses is neither very long nor very complicated.

The Author. In regard to Mr. Willard's objections that the method is complicated and that I have made an assumption in regard to the eccentricity of the loading, I think the fact that the method is complicated has no bearing on the question of whether the center of a rod or a point 0.6 of its length from one end is the proper place for the largest section. If there are analytical methods for designing a rod which are simpler and answer this question with equal cer-

tainty, I should like to learn of them. The assumption made by everyone that the eccentricity of loading, $e = o$, is no less an assumption than taking $\frac{ce}{r^2} = 0.6$. I am willing to admit, however, that this may give values too large for e, because the workmanship in connection rods would be on the average, much better than in the case of the columns considered by Moncrieff.

It has been stated that the maximum bending moment was approximately at 0.6 of the length of the rod from the end. This value of 0.6 (usually quoted from Grashof, but also derived by Bach) is obtained by assuming a rod of constant section; but even then it is not correct for a horizontal engine, since, as pointed out by Marks, the static weight of the rod brings the point of maximum bending moment nearer the center. As shown by the graphical method, neither the maximum bending moment nor the maximum stress is exactly at 0.577 of the length of the rod from the end. The exact locations of moment and of stress would undoubtedly depend on the amount of taper to the rod, and the amount of taper is usually a matter of judgment rather than of calculation. Some method seems to be required, therefore, which will indicate the correct amount of taper to use instead of being obliged to rely wholly on judgment in the matter.

GAS POWER SECTION

PRELIMINARY REPORT OF LITERATURE COMMITTEE

(V)

ARTICLES IN PERIODICALS

Brennstoffe im Gasgenerator, Die Vergasung Minderwertiger, Gwosdz. *Braunkohle, January 27, February 3, 1911.* 11 pp., 10 figs., 4 tables. *abfB.*

Comparative data on heating value of minor-grade fuels. Describes various systems where low-grade fuels as coal dust, coke dust, cinder, gathered from locomotive boiler flues, wet peat and wood shavings are utilized economically in the gas producer.

Carburetters and Vaporizers, T. A. Borthwick. *Cassier's Magazine, February 1911.* 6 pp., 7 figs. *abf.*

Discusses various forms used in the development of the combustible motor for converting liquid combustible into a gaseous state.

Costs in Industrial Power Plants, Comments on Fixed, John C. Parker, *Proceedings A.I.E.E., March 1911.* 16 pp., 6 tables, 1 curve.

Last part of article refers especially to gas-engine and producer plants.

Drehkolben-Verbrennungsmaschinen, Über, W. Gentsch. *Die Turbine. January 20, February 5, 1911.* 17 pp., 58 figs. *abd.*

Deals with rotating-piston internal-combustion machines.

Drehrost-Gaserzeuger Bauart Hilger, Der, Georg Kassel. *Stahl and Eisen, January 19, 1911.* 4 pp., 6 figs., 2 tables. *ab.*

Deals with revolving-grate gas generator; gives diversity of opinion as to value of water-jacket cheaper to install and operate without the jacket.

Efficiency of a Two-Cycle Engine, The Thermal. *The Gas Engine, March 1911.* 2 pp., 3 tables.

Extracts of paper by W. Watson and R. W. Fenning, before the English Institution of Automobile Engineers. Tables show results of test at several speeds and corresponding piston speeds and mean effective pressure in lb. per sq. in.

Opinions expressed are those of the reviewer, not of the Society. Articles are classified as: *a* comparative; *b* descriptive; *c* experimental; *d* historical; *e* mathematical; *f* practical. A rating is occasionally given by the reviewer, as *A*, *B*, *C*. The first installment was given in The Journal forMay 1910.

ENGINE, A NEW AJAX GAS. *Power, January 24, 1911.* 2½ pp., 6 figs.

ENGINES AT THE BRUSSELS EXHIBITION, INTERNATIONAL COMBUSTION, Percy R. Allen. *Cassier's Magazine, February 1911.* 21 pp., 20 figs. *bdfa.* Also *March 1911.* 31 pp., 31 figs., 1 table. *bf.*

First describes gas engines, producers and the Humphrey pump; detailed description of Cocherill twin-tandem engine, Ballinckx suction gas producer, Crossley engine and producer, Campbell engine and producer, Ruston and Proctor engine, valve gear and producer. Second describes liquid fuel engines; detailed description of Diesel engines, Brons vertical engine, Daimler reversible marine engine, Blackstone engine, Crossley reversing gear, Campbell crude-oil engine and vaporizer, Ruston and Proctor engine, oil, feed and valve gear, and others, with indicator cards, etc.

ENGINES, LARGE TWO-CYCLE GAS. *The Engineer (London), March 3, 1911.* 1. p., 3 figs.

Extract of paper by Alan E. L. Chorlton, before the Manchester Association of Engineers. Treats of large two-cycle internal-combustion engines, their design, redesign and erection; also a description of exhaust boilers in connection with gas engines and their location relative to the engines.

EXPLOSIONSMASCHINEN MIT WASSEREINSPRITZUNG, K. Schreber. *Die Gasmotorentechnik, January 1911.* 2½ pp., 1 fig.

FOUR A COKE, LE CHAUFFAGE DES FOUR MARTIN PAR DU GAZ DE, EM. TRASENSTER. *Revue Universelle des Mines, de la Métallurgie, November 1910.* 4 pp., 2 tables.

Heating of a Martin furnace by the gases from a coke oven.

FUELS, THE CALORIFIC VALUE OF SOLID AND LIQUID, W. Inchly. *The Engineer (London), February 17, 1911.* 2 pp., 2 tables, *ce.*

Criticism of existing formulae and analyses of different fuels.

GASOLINE AND THE IMPURITIES THAT ARE BEING ENCOUNTERED, COMMERCIAL. F. H. Floyd. *The Gas Engine, February 1911.* 6 pp., 2 tables.

GASREINIGUNGSVERFAHREN, ÜBER EIN NEUES, Friedrich Müller. *Stahl und Eisen, February 9, 1911.* 3 pp., 1 fig., 1 table, 4 curves. *ab.*

Comparative costs of installation and of operation of wet and dry methods of scrubbing.

GASWERKE IN LONDON, EDINBURGH, GLASGOW. *Journal für Gasbeleuchtung und Wasserversorgung, February 11, 1911.* 5 pp., 10 figs., *abf.*

Report and description of municipal gas plant.

GAZOGENER RÉCENTS QUELQUES, Gustave Richard. *Revue de Méchanique, December 31, 1910.* 40 pp., 60 figs., 3 tables. *A.*

Exhaustive article on modern gas producer.

GENERATOREN FÜR MINDERWERTIGE BRENNSTOFFE, DIE, Gwosdz. *Die Gasmotorentechnik, February 1911.* 3 pp., 2 figs. *b.*

JUNTAS Y EMPAQUETADURES EN LOS MOTORES DE GAS. *El Comercio, January 15, 1911.* ½p.

Manner of placing and maintaining joint-packing for gas engines. Gives preference to ground joints.

MOTEUR À EXPLOSIONS SYSTÈME ROOTS, G. Noël. *Fer et Acier, January 1911.* 3 pp., 4 figs. *bf.*

Describes remarkable arrangement of cylinders, pistons, etc., of a new gasolene motor.

PATENTE AUS DEM VERBRENNUNGS-MASCHINENBAU, NEUERE, R. Barkow. *Dinglers Polytechnishes Journal, February 18, 1911.* 3½ pp., 16 figs. *bf.*

New valve arrangement for large gas engines.

POWER PLANT AT HONG-KONG, A LARGE GAS. *The Engineer (London), February 24, 1911.* 2½ pp., 6 figs. *bf.*

Describes installation of Cocherill-Westgarth engines and Mond gas producers at the Taikoo dockyard.

POWER-PLANT DEVELOPMENT IN EUROPE, FEATURES OF PRODUCER-GAS, R. H. Fernald. *The Gas Engine, March 1911.* 5 pp.

Extract from Bulletin 4, U. S. Bureau of Mines. Details of several plants giving kind and number of producers, engines and scrubbers used; also kind of fuel and cost.

POWER, SOME PERTINENT FEATURES RELATING TO GAS, E. D. Dreyfus. *The Electric Journal, January 1911.* 11 pp., 3 figs., 3 tables, 4 curves.

Extract of paper before the Pittsburg Railway Club. Comparison of different power gases, economic value as compared with steam power. Notes on different types of engines and producers, maintenance and installation costs.

POWER, THE COST OF INDUSTRIAL, Aldis E. Hibner. *Proceedings A.I.E.E., March 1911.* 11 pp., 3 tables, 4 curves. *a.*

PRODUCER, THE HILGER REVOLVING GRATE GAS. *The Iron Age, March 2, 1911.* 1 p., 3 figs., 1 table. *b.*

Grate with forward and backward motion; patented ash removal device. Analyses of gas obtained with this producer.

VÁLVULAS DE LOS MOTORES DE GAS. *El Comercio, January 15, 1911.* ½ p. *b.*

Alleged faulty designs and suggestions for better construction.

VALVE SYSTEMS, NOVELTIES IN, E. P. Batzell. *The Gas Engine, February 1911.* 8 pp., 8 figs., 1 curve.

Paper before the Society of Automobile Engineers, New York. Discussion on the various types of valves and their application to small engines.

VERBRENNUNGSKRAFTMASCHINEN, DIE REVERSIERUNG VON, Ernst Valentin. *Die Gasmotorentechnik, February 1911.* 3 pp. 7 figs. *ab.*

GENERAL NOTES

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

At a meeting of the American Institute of Electrical Engineers to be held in Toronto, Ont., April 7, a paper will be presented by W. S. Murray, electrical engineer of the N.Y.N.H. & H.R.R. Co., entitled Analysis of Electrification and Its Practical Application to Trunk Lines for Freight and Passenger Operation. At the April 14 meeting of the institute in New York, two papers will be presented on the general subject of The Effect of Temperature upon the Hysteresis Loss in Sheet Steel, by Malcolm MacLaren, professor of electrical engineering at Princeton University, and by L. T. Robinson of the General Electric Company. A Pacific Coast meeting will be held at Los Angeles, Cal., April 25–28, at which the following papers will be presented: The Refining of Iron and Steel by Induction Type Furnaces, C. T. Elwell; Auto-Manual Telephone System, E. E. Clement; New Automatic Telephone Equipment, C. S. Winston; Continuity of Service in Transmission Systems, M. T. Crawford; Transmission Systems from the Operating Standpoint, R. J. C. Wood; A Power Diagram Indicator for High-Tension Circuits, H. J. Ryan, Mem.Am.Soc.M.E.; Electricity in the Lumber Industry, E. J. Barry; Transmission Applied to Irrigation, O. H. Ensign and J. M. Gaylord; Some Recent Developments in Railway Telephony, G. Brown; Cisoidal Oscillations, G. A. Campbell.

AMERICAN SOCIETY OF CIVIL ENGINEERS

At the bi-monthly meeting of the American Society of Civil Engineers on March 1, Albert R. Raynor read a paper on The Pittsburg and Lake Erie Cantilever Bridge over the Ohio River at Beaver, Pa. On March 15, a paper on Dams on Sand Foundations; Some Principles Involved in Their Design and the Law Governing the Depth of Penetration Required for Sheet Piling was presented.

The society's excursion to Panama began March 2, with the sailing of the United Fruit Company's steamer, Zacapa, from New York. The party was to be joined in Panama by a second one sailing from New Orleans, La., March 4.

It has been announced that the next annual convention of the society will be held at Chattanooga, Tenn., June 13–16.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION

The annual convention of the American Railway Engineering and Maintenance of Way Association was held in Chicago, Ill., March 21 to 23, with headquarters at the Hotel Congress. Reports on the following were presented: Rules and Organization, Signals and Interlocking, Electricity, Brine Drippings from Refrigerator Cars, Yards and Terminals, Wooden Bridges and Trestles,

Iron and Steel Structures, Economics of Railway Location, Ballast, Ties, Track Rail Masonry, Water Service, Signs, Fences and Crossings, Records and Accounts, Wood Preservation, Grading Rules for Maintenance of Way Lumber, Buildings, Roadway, Uniform General Contract Forms, Conservation of Natural Resources. An illustrated lecture on Steel Rails was given by M. H. Wickhorst. The Railway Signal Association and the Railway Appliance Association held meetings and exhibitions in Chicago at the same time and members of the America Railway Engineering and Maintenance of Way Association attended many of their sessions.

NORTHWESTERN CEMENT PRODUCTS ASSOCIATION

At the seventh annual convention of the Northwestern Cement Products Association in Minneapolis, Minn., February 28–March 1, papers were presented as follows: Stucco Finishes, E. McCullough; Cement Drain Tile Plants, C. M. Powell: Economies in Concrete Products, M. T. Roche: Manufacture of Cement Drain Tile, C. E. Sims; Cast Stone Work, C. A. P. Turner; Reinforced Concrete Construction in Minneapolis, J. Houghton; Concrete Highwater Bridges, A. E. Lindau.

CHEMISTS' CLUB

The Chemists' Building at 50 East 41st Street, New York, was inaugurated March 17. It is intended not only to supply the social needs of the Chemists' Club, but to serve also as a meeting place for the New York section of the American Chemical Society. The Institute of Chemical Industry and the American Electrochemical Society will also hold meetings in the new building. The ground floor is devoted to a public entrance hall and foyer, back of which is a large lecture room. On the next floor are a social room and restaurant of the Chemists' Club and on the floor above this are the library, the museum and the trustees' room. The fourth and fifth floors are occupied by members' bedrooms. The five floors constituting the upper half of the building are devoted to laboratories completely equipped for investigators in pure and applied science.

The program of opening exercises extended over three days and consisted in part of addresses by many prominent in the world of chemistry and lectures on Rare Gases of the Atmosphere, R. B. Moore; Characteristics of Living Matter from the Physico-Chemical Point of View, J. Loeb; Mental Catalysis, W. R. Whitney; Chemistry of Phosphorescence, W. D. Bancroft; The Contribution of Chemistry to Sanitation, W. P. Mason; The History of Chemical Industry in New York City, C. F. Chandler. A banquet in the new club rooms and a classical concert concluded the exercises.

CANADIAN CEMENT AND CONCRETE ASSOCIATION

The third annual convention of the Canadian Cement and Concrete Association was held in Toronto, Canada, March 6 to 9. The Toronto Cement Show, under the auspices of the Canadian Cement and Concrete Association, was in progress at the same time at the St. Lawrence Arena, and added much to the interest of the occasion. The convention was opened with an address by the president, Peter Gillespie, on Theory of Construction. Other papers read were

Concrete Blocks, R. F. Havlick; Grading Stone Aggregate, H. P. Bowes; Manufacture of Portland Cement, W. M. Kinney; The White and the Gray, J. M. Carrere; Prevention of Corrosion in Metal Lath, C. W. Noble; The Necessity of Inspection in Concrete Work, E. A. James; Concrete in Factory Construction, B. H. Prack; Cement Concrete in Highway Construction, W. A. McLean; Cement Surfaces and Finishes, Robt. Cathcart; A Few Points on Reinforced Concrete Design, C. S. L. Hertzberg. At the joint session with the Engineers' Club of Toronto there were two papers presented, one on Building By-Laws and Reinforced Concrete, Richard L. Humphrey; and another on Adaptation of Concrete for Long Span Bridges, Frank Barber.

CANADIAN MINING INSTITUTE

At the annual meeting of the Canadian Mining Institute held at the Chateau Frontenac, Quebec, Que., March 1–3, papers were presented on The Engineering Problems of Geological Nature Afforded by the New Catskill Aqueduct of New York City, J. F. Kemp; Asbestos Deposits of the New England States, C. H. Richardson; A New Type of Electrically Driven Long-Wall Machine, G. D. Burchell; and many others. An excursion to Montmorency Falls was enjoyed by the members attending the meeting.

PERSONALS

Charles H. Baker has been appointed chief engineer, Zylonite Power Station of the Boston & Maine Railroad, Adams, Mass. He was recently assistant chief engineer, Cos Cob Power Station, Cos Cob, Conn.

Charles H. Bigelow, recently associated with Charles T. Main, Boston, Mass., has become connected with the Yale & Towne Manufacturing Co., Stamford, Conn., as assistant superintendent of Power and Plant.

George L. Bourne, formerly vice-president of the Railway Materials Co., Chicago, Ill., has become connected with the Locomotive Superheater Co. of the same city, in a similar capacity.

Sterling H. Bunnell, recently associated with the Griscom-Spencer Co., New York, has been appointed consulting engineer of the Clinton H. Scovell Co., New York.

E. L. Hill, formerly assistant engineer in the district manager's office of the American Steel & Wire Co., Worcester, Mass., has been recently appointed assistant superintendent of the company's electrical cable work in that city.

M. W. Hogel, until recently engineer of tests at the Indiana Steel Co., Gary, Ind., has accepted the position of assistant works manager of The T. H. Symington Co., Rochester, N. Y.

G. L. Kothny has left the employ of the British Westinghouse Electric & Manufacturing Co. to accept the position of manager of the Great Britain Société Anonyme Westinghouse, London, England.

Grant W. Lillie has become assistant superintendent of the Oregon Short Line Railroad Co., Pocatello, Idaho. He was formerly superintendent of shops, St. Louis & San Francisco Railroad, Springfield, Mo.

W. G. Lunger has resigned his position as manager of the Chicago branch of the Union Twist Drill Co. to accept the position of manager of the furnace department of the American Shop Equipment Co., Chicago, Ill.

Henry B. Oatley formerly associated with the American Locomotive Co., Schenectady, N. Y., as assistant engineer of the general drawing room, has become affiliated with the Locomotive Superheater Co., New York.

William F. Parish, Jr., recently connected with the Deutsche Vacuum Oil Co., Hamburg, Germany, as chief engineer, has become associated with The Texas Co., New York.

Percy A. Robbins has become identified with the Hollinger Gold Mines, Porcupine, Ontario, Canada. He was formerly connected with the McKinley-Darragh Mine, Cobalt, Canada, in the capacity of general manager.

Max Rotter has become affiliated with Busch-Sulzer Bros., Diesel Engine Co., St. Louis, Mo., in the capacity of chief engineer. Mr. Rotter was formerly connected with the Allis-Chalmers Co., Milwaukee, Wis., in the same capacity.

Col. Edwin A. Stevens has been appointed Commissioner of Public Roads of New Jersey.

ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society, included in the Engineering Library. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am.Soc.M.E.

American Producer Gas Practice and Industrial Gas Engineering. By Nisbet Latta. *New York, D. Van Nostrand Co., 1910.*

The American Society of Mechanical Engineers. Year Book. 1911. *New York, 1911.*

Boletin de Ingenieros. Vol. 1. No. 6. February, 1911. *Mexico, 1911.*

Boston Transit Commission. 16th Annual Report. 1910. *Boston, 1910.* Gift of the commission.

Chemistry and Testing of Cement. By C. H. Desch. *London, E. Arnold, 1911.*

Commission des Méthodes d' Essai des Matériaux de Construction. 2d Session. Vols. 2–3. *Paris, 1900.*

Contracts in Engineering. By J. I. Tucker. *New York, McGraw-Hill Book Co., 1910.*

Cornish Magazine. *Truro.* Gift of R. I. Kirton.

De Laval Steam Turbines for both High and Low Pressure. (Reprinted from Iron Age.) *Trenton.* Gift of De Laval Steam Turbine Co.

Design of Electric Overhead Cranes, Crabs, Gearing and Brake Mechanism. By R. B. Brown. ed. 2. *New York, Industrial Press, 1910.*

Detroit Board of Water Commissioners. 58th Annual Report. 1910. *Detroit, 1910.* Gift of the board.

Eisenkonstruktionen der Ingenieur-Hochbauten. 4 Jahrgang. *Leipzig, 1909.*

Gas Petrol and Oil Engine. By Dugald Clerk. Vol. 1. *New York, J. Wiley & Sons, 1909.*

Heat Engines. By J. R. Allen and J. A. Bursley. *New York, McGraw-Hill Book Co., 1910.*

Illinois Mine Rescue Station Commission. Report to the Governor and General Assembly. From August 1, 1910 to December 31, 1910. *Springfield, 1911.* Gift of the commission.

Influence of Multi-Point Ignition on the Efficiency and Output of Internal-Combustion Engines. By Otto Heins. *New York, 1911.* Gift of Bosch Magneto Co.

Insurance Library Association of Boston. Bulletin. January 1911. Gift of the association.

International Congress of Applied Chemistry. 8th Preliminary Announcement. Opening meeting, September 4, 1912. Gift of the congress.

Machine Design. By A. W. Smith and G. H. Marx. ed. 3. *New York, J. Wiley & Sons, 1909.*

MACHINE SHOP DRAWING. By F. H. Colvin. *New York, McGraw-Hill Book Co., 1909.*

MECHANICS' AND ENGINEERS' POCKET BOOK. By C. H. Haswell. ed. 74. *New York, Harper & Bros., 1909.*

METALLOGRAPHIE. By W. Guertler. Vol. 1. pt. 5.

MICHIGAN ELECTRIC ASSOCIATION. Proceedings. 1910. *Port Huron, 1910.* Gift of the association.

MISSOURI WATERWAY COMMISSION. 1st Biennial Report. 1911. *Jefferson City, 1911.* Gift of the commission.

MODERN METHODS OF WATER PURIFICATION. By John Don and John Chisholm. *London, E. Arnold, 1911.*

NEW YORK CITY DOCKS AND FERRIES DEPARTMENT. Reply to Criticisms of Reports of the Department of Docks and Ferries relating to Manhattan Terminals at the Port of New York. *New York, 1910.*

——Report accompanying Submission of Plans for an Elevated Freight Railroad Connecting Manhattan Terminals at the Port of New York. *January 26, 1911.*

——Report on Transportation Conditions at the Port of New York. *July 1910.*

——Supplementary Report on Manhattan Terminals at the Port of New York. *New York, 1910.*

NEW YORK STATE COMMISSIONER OF EXCISE. Report of Maynard N. Clement. 1910. *Albany, 1911.* Gift of the author.

PARALLEL TABLES OF LOGARITHMS AND SQUARES. By C. Smoley. ed. 6. *New York, Engineering News Pub. Co., 1911.*

RAILROADS AND THE PEOPLE. By E. P. Ripley. (Reprinted from the Atlantic Monthly, January 1911.) *Boston, 1911.*

VISIT TO HIS MAJESTY'S MINT, CALCUTTA, BY KIND INVITATION FROM CAPT. G. H. WILLIS, JANUARY 21, 1911. By A. Dryden. (Reprinted from the Institution of Mechanical Engineers.) Gift of the author.

WATER POWER FOR THE FARM AND COUNTRY HOME. By D. R. Cooper. *Albany.* Gift of State of New York Water Supply Commission.

WATUPPA WATER BOARD. 37th Annual Report to the City Council of the City of Fall River, Mass. 1911. *Fall River, 1911.* Gift of Fall River Water Works.

WELDING, THEORY, PRACTICE, APPARATUS AND TESTS. By R. N. Hart. *New York, McGraw-Hill Book Co., 1910.*

UNITED ENGINEERING SOCIETY

COAL MINING INSTITUTE OF AMERICA. Proceedings. 1908, 1909. Gift of the Institute.

CONGRESSIONAL DIRECTORY. 61st Congress. 3d Session. 1911. *Washington, 1911.* Gift of Senator Elihu Root.

PENNSYLVANIA RAILROAD COMPANY. Specifications. Nos. 1–*C*; 2; 3–*A*; 4–*A*; 5–*A*; 6; 7–*C*; 8; 9–*F*; 10–*D*; 11–*C*; 12–*F*; 13; 14–*C*; 15; 16; 17; 18; 20–*A*; 21; 22–*A*; 23–*A*; 24–*A*; 25–*B*; 26; 27–*A*; 28–*A*; 29–*F*; 30–*A*; 31–*A*; 32–*C*; 33–*F*; 34–*A*; 35–*A*; 36–*A*; 38–*A*; 39–*C*; 40–*A*; 41–*A*; 42; 43–*A*; 44–*D*; 45–*A*; 46–*B*; 47; 48; 49–*A*; 50; 52–*A*; 53; 54–*C*; 55–*A*; 56; 57; 59–*B*; 60–*B*; 61; 62; 64; 65; 66; 72; 73; 74–*A*; 75–*A*; 78; 78–*B*; 80–*A*; 88–*A*; 101; 102; 104; 106–*C*; 107–*A*; 120; 121; 122. Gift of the company.

RECOMMENDATIONS AND GENERAL PLANS FOR A COMPREHENSIVE PASSENGER SUBWAY SYSTEM FOR THE CITY OF CHICAGO. By B. J. Arnold. *January 1911.* Gift of the author.

SAN FRANCISCO ASSOCIATION OF MEMBERS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS. Constitution and List of Members, 1911.

TEST OF A PARSONS TYPE STEAM TURBINE. By R. C. Carpenter. (Reprinted from Sibley Journal of Engineering, January 1911.) Gift of the author.

TRAVELING ENGINEERS' ASSOCIATION. Proceedings of 4th, 6th, 8th–14th and 17th Annual Conventions. 1896, 1898, 1900–1906, 1909. Gift of the association.

TREATISE ON MASONRY CONSTRUCTION. By I. O. Baker. ed. 10. *New York, J. Wiley & Sons, 1910.*

UNIVERSITY OF CINCINNATI. Catalogue. 1910–1911. *Cincinnati, 1910.*

VALVE SETTINGS. By H. E. Collins. *New York, McGraw-Hill Book Co., 1908.*

EXCHANGES

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS. Transactions. Vols. 1–3. 1905–1907. *New York.*

INCORPORATED INSTITUTION OF AUTOMOBILE ENGINEERS Proceedings. Vol. 4, 1909–1910. *Westminster, 1910.*

JUNIOR INSTITUTION OF ENGINEERS. Journal and Record of Transactions. Vol. 20. 1909–1910. *London, 1910.*

SÄCHSISCHER DAMPFKESSEL-REVISIONS-VEREIN CHEMNITZ. Ingenieur Bericht, 1910. *Chemnitz, 1910.*

TRADE CATALOGUES

BRISTOL CO., *Waterbury, Conn.* Bull. no. 127, Bristol's Class 3 recording thermometers, 39 pp.

JOHN W. FERGUSON CO., *Paterson, N. J.* Photographs of work executed by the company, 108 pp.

LAGONDA MFG. CO., *Springfield, O.* Weinland tube cleaners, 48 pp.

LEHIGH CLUTCH CO., *Catasauqua, Pa.* Friction clutches, 3 pp.

F. E. MYERS & BROS., *Ashland, O.* Pumps, agricultural implements and tools, 404 pp.

NATIONAL ELECTRIC LAMP ASSOC., *Cleveland, O.* Bull. no. 15, Electric Sign Lighting, 15 pp.; Bull. no. 8*B*, Mazda miniature and low-voltage lamps, 11 pp.; Bull. no. 5*C*, Tantalum multiple lamps, 11 pp.

NATIONAL WATER SOFTENER SALES CO., *Indianapolis, Ind.* Water softeners, 15 pp.

L. H. NIELSON, *Pittsburg, Pa.* Safety operator for elevators, 16 pp.

OHIO BRASS CO., *Mansfield, O.*, Bull., Jan.–Feb. 1911, Electric railway and mine haulage material, 24 pp.

PLATT IRON WORKS CO., *Dayton, O.* Smith-Vaile air compressors, steam and power actuated, 39 pp.; Smith-Vaile boiler feed pumps, 35 pp.; Victor-Francis turbines, 24 pp.

Pott, Cassels & Williamson, *Motherwell, Scotland.* Water-driven centrifugals "Weston" type with patent interlocking gear, 23 pp.; Catalogue of centrifugal machinery, 170 pp.

Precision Instrument Co., *Detroit, Mich.* Precision Simmance-Abady CO_2 combustion recorder, 16 pp.

Standard Scale & Supply Co., *Pittsburg, Pa.* Catalogue of standard scales, 128 pp.

Stephens-Adamson Mfg. Co., *Aurora, Ill.* The Labor Saver No. 33, devoted to labor saving devices, 24 pp.

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 12th of the month. The list of men available is made up of members of the Society and these are on file, with the names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

079 Wanted, by Ohio company building stationary engines, energetic and competent engineer to take charge of the shop as superintendent. Must be familiar with modern methods of turning out work and able to put them into practice. Good opportunity for the right man.

080 Chief draftsman for plant engaged in automobile work, desirable that applicant have had experience in this line of work, although not so essential as that he be energetic, thorough and reliable and have had experience in charge of drafting room. Willing to pay right man what he is worth. Location, New England states.

081 Machine designer with both technical and shop training, designing high-speed machines along new lines, requiring initiative, ingenuity, good judgment as to the use of materials and construction and thorough knowledge of shop and foundry work. To man of right experience, permanent position with every possibility of advancement if value is proved. Location, Michigan.

082 In engineering department of large steel company, assistant steam engineer. Technical graduate having at least four years' experience in similar lines. Location, Pennsylvania.

083 Superintendent of factory manufacturing brass goods, mainly sheet metal work. Will be required to reorganize and bring up to date entire factory system under principles of scientific management. Location, Connecticut.

MEN AVAILABLE

179 Technical graduate, age 33, 12 years' practical experience in mechanical department of railroads from machinist apprentice to superintendent of motive power. Executive ability and considerable experience in handling men. Desires responsible position with railroad or large manufacturing concern.

180 Mass. Inst. Tech. graduate, '97, fourteen years' experience in manufacturing, involving machine, foundry and boiler shop practice, desires change with view to bettering present conditions.

181 Graduate mechanical engineer; assistant professor of mechanical engineering and superintendent of shops in state university; desires position on faculty of technical college or university. Seven years' experience in teaching, and wide experience in all branches of shop practice.

182 Mechanical and structural engineer, wide experience in charge of design of furnace and rolling mills, general steel plant construction; desires position as chief draftsman or assistant engineer.

183 Member, 12 years' experience, machine, mill equipment, power plant design and field work. Good office experience. Chief draftsman, technical and practical training; desires change of position.

184 Position desired with construction firm or manufacturing company, machinery line preferred, as assistant to superintendent or manager. Thoroughly experienced in office detail, cost systems, etc., considerable experience in field construction work. Age 32, married.

185 Mechanical engineer, eight years' standing, one year additional in electrical engineering; now in charge of six large plants; desires position with power production or manufacturing concern vicinity of New York.

186 Mechanical engineer with several years' experience in engine works; past ten years head of strong engineering college in prominent university, desires a change. Responsible teaching position preferred.

187 Associate member, chief draftsman, designer or shop superintendent, expert in machine work, tool and manufacturing; good organizer and system man on shop costs and production; resourceful in design and processes for increasing production small and medium heavy interchangeable work. Location, New Jersey or New York.

188 Member, desires to connect with manufacturing, contracting or engineering firm, in any capacity requiring mature judgment and executive ability. Has had wide experience in mechanical work and some electrical, from drafting room to supervision. Sales engineer during past three years. Technical graduate, age 33. Position requiring progressive business ability as well as technical capacity desired. Location, Philadelphia.

189 Member, age 46; present occupying an executive position with large machinery manufacturers, desires engagement with either manufacturing or selling departments of live, growing concern. Engines, turbines, electrical machinery, power transmission or similar lines.

190 Mechanical engineer, 15 years' practical experience designing and building various lines of heavy machinery, competent to manage large engineering proposition. Now engineering executive for large corporation.

191 High class electrical engineer, age 30, desires to locate as office partner to consulting mechanical engineer with office in New York.

192 Member, 20 years' experience in engineering educational work, including shops, drafting, lectures, laboratory and administration, with special reference to mechanics, steam, hydraulic and industrial engineering, and power plants; open to engagement at close of present term of contract.

193 Junior, technical graduate in mechanical engineering, several years' practical experience in general drafting and engineering work; desires to make change. At present employed as mechanical draftsman. Desires to locate in or near New York.

194 Graduate M.E., age 25, employed as instructor in mechanical engineering in prominent eastern university; shop, drafting-room and office experience; prefers position as assistant superintendent, engineer or assistant professorship.

195 Graduate mechanical engineer, four years' standing, experienced in factory installation and mechanical superintendence; desires connection with large interests in capacity leading to position of mechanical superintendent of works or mill engineer.

196 Affiliate member, technical education, shop experience four and one-half years, drafting-room five years, gas and gasolene engines and gas producers. Design and construction of gas tractors, stationary engines and automobiles. Desires position as superintendent or assistant superintendent where knowledge of design and modern practice will be of value.

197 Mechanical engineer and designer of pumping machinery and water works installations; desires to make change. Nineteen years' experience designing and estimating on pumps, condensers and complete water works plants.

198 Junior, age 28, married, technical education; practical machinist, nine years as draftsman, designer, chief draftsman and general superintendent with present concern, building heavy machine tools and special machinery on interchangeable basis. Desires position as superintendent or manager. Salary, $2400.

CHANGES IN MEMBERSHIP

CHANGES OF ADDRESS

ALEXANDER, Ludwell Brooke (Junior, 1905), Asst. Ch. of Dept., Bosch Magneto Co., 223 W. 46th St., and Cliffwood Court, 179th St., and Ft. Washington Ave., New York, N. Y.

AUE, Joseph E. (1899), Snow Steam Pump Wks., Buffalo, and *for mail*, 2968 Decatur Ave., New York, N. Y.

BAILEY, William J. (Junior, 1910), United Coal Co., Pa. Bldg., Philadelphia, Pa.

BAKER, Charles H. (Junior, 1903), Ch. Engr., Boston & Maine R. R., Zylonite Power Sta., Adams, Mass.

BIBBINS, James Rowland (1904; 1909), Engr. with Bion J. Arnold, 154 Nassau St., New York, N. Y., and Council Clerks Office, City Hall, Providence, R. I.

BIGELOW, Charles H. (1904), Asst. Supt., P. & P., Yale & Towne Mfg. Co., Stamford, Conn.

BOURNE, George L. (1903), V. P., Loco. Superheater Co., Peoples Gas Bldg., and 5133 Ellis Ave., Chicago, Ill.

BRADLEY, Carl D. (1907), Pres., Samuel L. Moore & Sons Corp., Elizabeth, N. J., and *for mail*, Machinery Club, 50 Church St., New York, N. Y.

BURCHARD, Anson W. (1888; 1891), 777 Madison Ave., New York, N. Y.

BUNNELL, Sterling Haight (1894; 1903), Cons. Engr., Clinton H. Scovell & Co., 90 West St., and 519 W. 121st St., New York, N. Y.

BURTON, Frank H. (1900), 6 Selkirk Rd., Brookline, Mass.

COOLEY, Hugh Nelson (Associate, 1910), Rep., Nordberg Mfg. Co. in Southwestern U. S. and Mexico, and *for mail*, No. 4, 1116 N. Oregon St., El Paso, Tex.

COWLES, William Barnum (1881), Industrial Expt. and Cons. Engr., 26 Alfred St., Detroit, Mich.

DURANT, Aldrich (Junior, 1906), MacArthur-Perks Co., Ltd., Havana, Cuba.

FLETEMEYER, Louis H. (Junior, 1906), Ch. Draftsman, Canada Fdy. Co., Ltd., and *for mail*, 41 Walter St., Toronto, Ont., Canada.

GAST, George Fred (Junior, 1910), Ch. Draftsman and Constr. Engr., with Walter Kidde, 140 Cedar St., New York, N. Y., and *for mail*, 2027 Oakland Ave., Minneapolis, Minn.

GREEN, Chas. Henry (Junior, 1905), 617 Peyton Bldg., Spokane, Wash.

HILL, Edgar Logan (Junior, 1908), Asst. Supt., Elec., Cable Wk., Am. Steel & Wire Co., and *for mail*, P. O. Box 553, Worcester, Mass.

HIRT, Louis Joseph (1894), Mech. Engr., Broad Exch. Bldg., 25 Broad St., New York, and *for mail,* 75 Farnham Ave., Yonkers, N. Y.

HOGLE, Milton W. (1901; Associate, 1906), Asst. Wks. Mgr., The T. H. Symington Co., and *for mail,* 128 Linden St., Rochester, N. Y.

HOY, Austin Y. (Junior, 1906,) Northwestern Mgr., Sullivan Mchy. Co., Hutton Bldg., and Pennington Hotel, Spokane, Wash.

KOTHNY, Gottdank Lebrecht (Junior, 1905), Mgr., Great Britain Societé Anonyme Westinghouse, 82 York Rd., Kings Cross, London, N., England.

LAPE, Willard E. (1890), care W. D. Garrett & Co., 136 Liberty St., New York, N. Y., and 109 Dodd Pl., East Orange, N. J.

LATTA, Nisbet (Junior, 1902), Wisconsin Eng. Co., Corliss, Wis.

LEE, R. E. (Junior, 1907), R. F. D. 2, Charlottesville, Va.

LEE, Wm. F. (1907), West New Brighton, S. I., N. Y.

LILLIE, Grant W. (Junior, 1901), Asst. Supt., Oregon Short Line R. R. Co., Pocatello, Idaho.

LUFKIN, Elgood Chauncey (1896), V. P., The Texas Co., 17 Battery Pl., New York, N. Y.

LUNGER, Waldo G. (Junior, 1901), Mgr., Furnace Dept., Am. Shop Equipment Co., McCormick Bldg., 193 Michigan Ave., Chicago, and 935 Hinman Ave., Evanston, Ill.

McMILLAN, Chas. M. (Junior, 1909), Gas Eng. Specialist, 1324 Arabella St., New Orleans, La.

MATTICE, Asa M. (1889), Manager, 1903-1906; Mgr. of Wks.. Walworth Mfg. Co., and *for mail,* 53 M St., South Boston, Mass.

MEYER, C. Louis (Junior, 1909), Trussed Concrete Steel Co., Terminal Bldg., Dallas, Tex.

MORRISON, Clarke J. (1909), Mech. Engr., 191 N. Walnut St., East Orange, N. J.

NILES, Francis H. (Associate, 1907), 5437 Cornell Ave., Chicago, Ill.

OATELY, Henry Bigelow (1910), Mech. Engr., Locomotive Superheater Co., 30 Church St., New York, N. Y.

PARISH, Wm. F. (1902; 1904), The Texas Co., 17 Battery Pl., New York, N. Y.

POTTS, S. Warren (1909), Mech. Engr., R. Hoe & Co., 504 Grand St., and *for mail,* 622 W. 135th St., New York, N. Y.

PRESSINGER, W. P. (Associate, 1903), Mgr. Compressor Dept., Chicago Pneumatic Tool Co., 50 Church St., and Orleans Hotel, 100 W. 80th St., New York, N. Y.

RIDGELY, William B. (1880; 1895), Pres., Witherbee Igniter Co., Springfield, Mass.

ROBBINS, Percy Arthur (Associate, 1901), Hollinger Gold Mines, Auva Lake P. O., Porcupine, Ont., Canada.

ROBESON, Anthony Maurice (1895), care A. Moir, 1 London Wall Bldgs., London, E. C., England.

ROTTER, Max (1899), Ch. Engr., Busch-Sulzer Bros.-Diesel Eng. Co., South Side Bank Bldg., St. Louis, Mo.

SHIPLEY, Grant B. (Associate, 1907), Pres. and Genl. Mgr., Pittsburg Wood Preserving Co., Pittsburg, Pa., and 477 Marshall St., Milwaukee, Wis.

WEEKS, Paul (Junior, 1905), 217 Mariposa Ave., Los Angeles, Cal.

WILLCOX, George Bingham (1895; 1908), Pres. and Genl. Mgr., Willcox Engrg. Co., Wilcox Engrg. Co. Bldg., and *for mail*, 900 S. Warren Ave., Saginaw, Mich.

WYMAN, Arthur H. (Junior, 1909), Sales Engr., Allis-Chalmers Co., and *for mail*, Flat 9, 227 13th St., Milwaukee, Wis.

NEW MEMBERS

ROSS, Sir Charles Henry A. F. L. (1910), Pres., Ross Rifle Co., Quebec, Canada.

ROSSMAN, James R., Jr. (Junior, 1910), Ch. Engr., Steel Cable Engrg. Co., Boston, and *for mail*, 1869 Beacon St., Brookline, Mass.

STEPHENS, Phinehas V. (1910), Constr. Dept., The Safety Insulated Wire & Cable Co., 114 Liberty St., New York, N. Y.

DEATHS

MASON, William B., February 4, 1911.

GAS POWER SECTION

CHANGES OF ADDRESS

AUE, Jos. E. (1908), Mem. Am. Soc. M.E.

BIBBINS, James Rowland (1908), Mem. Am. Soc. M.E.

DOW, Benjamin W. (Affiliate, 1909), Stone & Webster Engrg. Corp., 147 Milk St., Boston and *for mail,* 7 Standish St., Dorchester, Mass.

GARDNER, F. M. (Affiliate, 1910), Engr. and Salesman, Fairbanks, Morse & Co., and *for mail,* S. W. cor. 8th and Main Sts., Cincinnati, O.

HOPKINS, George Jay (Affiliate, 1909), Berlin Mch. Wks., 1125 Marquette Bldg., Chicago, and *for mail,* 230 S. Maple St., Sycamore, Ill.

LATTA, Nisbet (1908), Mem.Am.Soc.M.E.

MOSES, Percival R. (Affiliate, 1909), Cons. Engr., 366 Fifth Ave., New York, N. Y.

SHOOP, R. B. (Affiliate, 1908), Draftsman, Austin Mfg. Co., Harvey, and *for mail,* Blue Island, Ill.

STUDENT BRANCHES

CHANGES OF ADDRESS

BINNS, Geo. W. (Student, 1910), 347 McMillan Ave., Cincinnati, O.
BREER, Carl (Student, 1909), 5031 National Ave., West Allis, Wis.
BRONSON, C. E. (Student, 1910), 141 Seneca St., Hornell, N. Y.
BUTLER, N. R. (Student, 1909), 710 Thurston Ave., Ithaca, N. Y.
CASTRO, Pedro B. (Student, 1910), 332 W. College Ave., State College, Pa.
FRIED, J. A. (Student, 1910), 90 Waite Ave., Ithaca, N. Y.
GRENOBLE, H. S. (Student, 1909), 4312 Champlain Ave., Chicago, Ill.
HAM, C. W. (Student, 1910), 415 N. Cayuga St., Ithaca, N. Y.
HEBBARD, L. L. (Student, 1910), 713 W. Dayton St., Madison, Wis.
HELWIG, Alfred (Student, 1910), 10th Ave. and 70th St., Brooklyn, N. Y.
JACOBSEN, C. H. (Student, 1910), 5031 National Ave., West Allis, Wis.
JENKINS, Harold B. ((Student, 1910), 16 Morningside Ave. E., New York.
KOWALEWSKI, A. J. (Student, 1910), 316 Main Bldg., State College, Pa.
LINDSAY, H. D. (Student, 1909), 258 Farwell Ave., Milwaukee, Wis.
MANSFIELD, W. M. (Student, 1909), Woodhull, Ill.
NIXDORFF, S. P. (Student, 1909), 194 Jay St., Schenectady, N. Y.
PARMLEY, H. M. (Student, 1910), 507 N. Aurora St., Ithaca, N. Y.
PEACH, P. L. (Student, 1909), 708 E. Seneca St., Ithaca, N. Y.
PEASLEE, W. (Student, 1910), 2539 Stratford Ave., Cincinnati, O.
PEMBERTON, Carlysle (Student, 1909), 619 N. James St., Rome, N. Y.
QUICK, R. L. (Student, 1909), 141 Washington St., Hartford, Conn.
RUEF, John (Student, 1911), 6044 Michigan Ave., Chicago, Ill.
SCHUSTER, George (Student, 1909), 313 Quincy St., Topeka, Kan.
SPONSLER, J. M. (Student, 1909), 109 John St., Champaign, Ill.
STEUDEL, Geo. E. (Student, 1910), 229 W. Gilman St., Madison, Wis.
STRAYER, T. Franklin (Student, 1910), 233 McAllister Hall, State College, Pa.
TEMPLIN, E. W. (Student), 1910, Univ. of Maine, Orono, Me.
WATROUS, Russell W. (Student, 1910), 558 Ashland Ave., St. Paul, Minn.
WATSON, H. L. (Student, 1910), 452 Cascadilla Pl., Ithaca, N. Y.
WHAREN, Geo. B. (Student, 1910), P. R. R. Sch. for Apprentices, Altoona, Pa.
WOOD, Stanley V. (Student, 1909), Bachelor Hall, Wilkinsburg, Pa.
YOAKUM, F. E. (Student, 1909), 78 Sheldon Court, Ithaca, N. Y.

NEW MEMBERS

ARMOUR INSTITUTE OF TECHNOLOGY

STRALE, Nels (Student, 1911), 1533 E. 65th St., Chicago, Ill.

COLUMBIA UNIVERSITY

GREF, W. H. (Student, 1911) 21 Claremont Ave., New York.

CORNELL UNIVERSITY

ATKINSON, K. (Student, 1911), Cascadilla Bldg., Ithaca, N. Y.
CHAPMAN, W. H. (Student, 1911), 116 Lake St., Ithaca, N. Y.
CLARK, E. (Student, 1911), 103 Catherine St., Ithaca, N. Y.
DAVIS, F. (Student, 1911), 706 E. Buffalo St., Ithaca, N. Y.
DOLL, W. E. (Student, 1911), 603 E. Seneca St., Ithaca, N. Y.
EASTWOOD, S. K. (Student, 1911), 120 Catherine St., Ithaca, N. Y.
GARNER, H. H. (Student, 1911), 325 Dryden Rd., Ithaca, N. Y.
HAMANT, M. J. (Student, 1911), 206 College Ave., Ithaca, N. Y.
HAY, E. H. (Student, 1911), 528 Stewart Ave., Ithaca, N. Y.
HENDRICKSON, G. S. (Student, 1911), 206 Dryden Rd., Ithaca, N. Y.
HICKOK, J. P. (Student, 1911), 317 College Ave., Ithaca, N. Y.
HUNT, C. W. (Student, 1911), 109 E. Seneca St., Ithaca, N. Y.
McELROY, R. C. (Student, 1911), 206 College Ave., Ithaca, N. Y.
MORROW, C. H. (Student, 1911), 205 Dryden Rd., Ithaca, N. Y.
MILLS, S. D. (Student, 1911), 127 Dryden Rd., Ithaca, N. Y.
MORSE, R. V. (Student, 1911), 512 Edgewood Pl., Ithaca, N. Y.
VERY, W. R. M. (Student, 1911), 119 Stewart Ave., Ithaca, N. Y.
WALLACE, F. R. (Student, 1911), 510 E. Seneca St., Ithaca, N. Y.
WHEELER, H. T. (Student, 1911), 317 College Ave., Ithaca, N. Y.
WICK, L. T. (Student, 1911), 73 Sheldon Courts, Ithaca, N. Y.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DREW, W. N. (Student, 1911), 201 Magnolia St., Roxbury, Mass.

OHIO STATE UNIVERSITY

ALLEN, L. E. (Student, 1911), 2036 N. High St., Columbus, O.
BECKBERGER, E. H. (Student, 1911), 155 W. 10th Ave,. Columbus, O.
BERK, E. R. (Student, 1911), 1500 Neil Ave., Columbus, O.
BIGGERT, E. F. (Student, 1911), 355 King Ave., Columbus, O.
BORNHORST, A. H. (Student, 1911), 355 King Ave., Columbus, O.
COCHRAN, R. E. (Student, 1911), 83 W. Lane Ave., Columbus, O.
EMRICK, A. A. (Student, 1911), 105 W. Lane Ave., Columbus, O.
FOSTER, O. F. (Student, 1911), 397 N. Monroe Ave., Columbus, O.
FRANCE, L. E. (Student, 1911), 747 Franklin Ave., Columbus, O.
GRIFFIN. F. S. (Student, 1911), 185 W. 9th Ave., Columbus O.
HATFIELD, G. D. (Student, 1911), 175 W. 10th Ave., Columbus, O.
HOPKINS. A. L. (Student, 1911), 185 W. 9th Ave., Columbus, O.
HYATT, Edw. (Student, 1911), 212 E. Frambes Ave., Columbus, O.
LIEBICH, A. T. (Student, 1911), 75 W. 10th Ave., Columbus, O.
LOK, K. H. (Student, 1911), 155 W. 10th Ave., Columbus, O.

McCLELLAND, C. C. (Student, 1911), 28 12th Ave., Columbus, O.
OWEN, R. D. (Student, 1911), 323 Linwood Ave., Columbus, O.
PAPE, L. R. (Student, 1911), 1576 Neil Ave., Columbus O.
PERKINS, L. A. (Student, 1911), 1321 Highland St., Columbus, O.
POHLMAN, I. H., Student, 1911), 57 W. 10th Ave., Columbus, O.
SHULER, H. A. (Student, 1911), 1500 Neil Ave., Columbus, O.
STIEHL, C. E. (Student, 1911), 1500 Neil Ave., Columbus, O.

PENNSYLVANIA STATE COLLEGE

ANNE, G. E. (Student, 1911), Frazier St., State College, Pa.
MORRISON, C. R. (Student, 1911), 312 Main Bldg., State College, Pa.

RENSSELAER POLYTECHNIC INSTITUTE

STUART, Milton C. (Student, 1911), R. P. I. Dormitory, Troy, N. Y.
SWAIN, Donald, B. (Student, 1911), 29 Park Ave., Troy, N. Y.

UNIVERSITY OF ARKANSAS

HAYS, C. W. (Student, 1911), 101 N. West St., Fayetteville, Ark.

UNIVERSITY OF ILLINOIS

BOYLE, Clarence, Jr., (Student, 1911), Taylor Iron & Steel Co. High Bridge, N. J.
DOUGLAS, R. T. (Student, 1911), 805 W. Illinois St., Urbana, Ill.,

UNIVERSITY OF KANSAS

KNERR, L. E. (Student, 1911), 1230 Oread Ave., Lawrence, Kan.

UNIVERSITY OF NEBRASKA

NOELTING, W. H. (Student, 1911), 1722 Q St., Lincoln, Neb.

UNIVERSITY OF WISCONSIN

BARNUM, C. T. (Student, 1911), 610 Langdon St., Madison, Wis.
ROBERTS, C. (Student, 1911), 620 State St., Madison, Wis.

YALE UNIVERSITY

AUSTIN, R. F. (Student, 1911), 135 Sheff. Vanderbilt, New Haven, Conn.
BEATTIE, J. J. (Student, 1911), 151 Sheff. Vanderbilt, New Haven, Conn.
CHILDS, W. St. C. (Student, 1911), 17 Hillhouse Ave., New Haven, Conn.
COONEY, L. S. (Student, 1911), 124 Prospect St., New Haven, Conn.
HYDE, T. R. (Student, 1911), 148 Grove St., New Haven Conn.
SCHMIDT, F. W. (Student, 1911), 107 Sheff. Vanderbilt, New Haven, Conn.
SELDEN, S. M. (Student, 1911), 124 Sheff. Vanderbilt, New Haven, Conn.
SWENSON, S. M. (Student, 1911), 133 College St., New Haven, Conn.
WINTON, L. B. (Student, 1911), 136 Canner St., New Haven, Conn.

COMING MEETINGS

April—May

Advance notices of annual and semi-annual meetings of engineering societies are regularly published under this heading and secretaries or members of societies whose meetings are of interest to engineers are invited to send such notices for publication. They should be in the editor's hands by the 15th of the month preceding the meeting. When the titles of papers read at monthly meetings are furnished they will also be published.

AIR BRAKE ASSOCIATION

May 23–26, annual convention, Auditorium Hotel, Chicago, Ill. Papers: Air Brake Instruction, Rating, T. Clegg, Geo. A. Wyman, H. H. Burns, H. A. Wahlert, T. F. Lyons; Brake Cylinders and Connections, H. A. Wahlert; Adequate Braking Power for Freight Cars, J. P. Kelly; Cost of Maintenance of Locomotive Brakes, W. P. Huntley; Running Triple Valves without Lubricant, L. Leonard; Fibre Stresses in Brake Gear Parts, G. O. Hammond; "PC" Equipment, W. V. Turner; Steel Pipe vs. Iron Pipe, J. R. Alexander; Recommended Practice, S. G. Down, G. R. Parker, H. A. Wahlert, N. A. Campbell, J. R. Alexander; Friction of New and Worn Brake Shoes on New and Worn Cast Wheels, A. S. Williamson; Breaking-in-two of Trains, S. H. Draper, P. J. Langan. Secy., F.M. Nellis, 53 State St., Boston, Mass.

AMERICAN FOUNDRYMEN'S ASSOCIATION

May 22–26, annual convention, Pittsburg, Pa. Secy., Richard Moldenke, Wachtung, N. J.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

April 14, monthly meeting, 29 W. 39th St., New York. Secy., R. W. Pope.

AMERICAN SOCIETY OF CIVIL ENGINEERS

April 5, 19, bi-monthly meetings, 220 W. 57th St., New York. Secy., C. W. Hunt.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Monthly meetings: April 11, 29 W. 39th St., New York; April 21, Boston, Mass.; April 22, Philadelphia, Pa. Spring Meeting, May 30–June 2, Pittsburg, Pa. Secy., C. W. Rice, 29 W. 39th St., New York.

AMERICAN RAILWAY INDUSTRIAL ASSOCIATION

May 9–10, annual meeting, Detroit, Mich. Secy., Guy L. Stewart, 1328 Pierce Bldg., St. Louis, Mo.

CANADIAN FREIGHT ASSOCIATION

April 13, annual meeting, Montreal, Que. Secy., T. Marshall, Toronto, Ont.

CONGRESS OF TECHNOLOGY

April 10-11, Massachusetts Institute of Technology, Boston, Mass.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

May 23–26, annual convention, Omaha, Neb. Secy., Harry D. Vought, 95 Liberty St., New York.

NATIONAL ASSOCIATION OF COTTON MANUFACTURERS

April 12–13, annual meeting, Mass. Inst. of Tech., Boston, Mass. Papers: Arbitration on Cancellation of Orders, By-Products in Cotton Manufacture, Doffing Machines and their Relation to Child Labor, Electric Power Transmission to Cotton Mills, Executive Management of the Textile Plant and its Relation to the Market, Gas Producers and Gas Engines for Cotton Mills, Illumination, Law of Moisture in Cotton and Wool, Methods of Cost Finding in Cotton Mills, Moisture in Cotton, Renaissance of the Waterfall, Rewinding Weft Yarn, Sandwich Island Cotton, Textile Education from a Manufacturing Standpoint, Weaving Shed Roof Construction. Secy., C. J. H. Woodbury, Mem.Am.Soc.M.E., P. O. Box 3672.

NATIONAL ELECTRIC LIGHT ASSOCIATION

May 29–June 2, annual convention, New York. Secy., T. C. Martin, 29 W. 39th St.

NATIONAL FIRE PROTECTION ASSOCIATION

May 23–25, annual meeting, New York. Secy., F. H. Wentworth, 87 Milk St., Boston, Mass.

NATIONAL METAL TRADES ASSOCIATION

April 12–13, annual convention, Hotel Astor, New York. Comr., Robert Wuest, New England Bldg., Cleveland, O.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS

May 18-19, semi-annual meeting, Youngstown, O. Secy., Frank E. Sanborn, Ohio State University, Columbus, O.

MEETINGS IN THE ENGINEERING SOCIETIES BUILDING

Date	Society	Secretary	Time
April			
6	Blue Room Engineering Society	W. D. Sprague	8.00 p.m.
11	American Society of Mechanical Engineers	C. W. Rice	8.15 p.m.
13	Illuminating Engineering Society	P. S. Millar	8.00 p.m.
13	Institute of Operating Engineers	M. W. Rice	8.00 p.m.
14	American Institute of Electrical Engineers	R. W. Pope	8.15 p.m.
18	New York Telephone Society	T. H. Lawrence	8.15 p.m.
21	New York Railroad Club	H. D. Vought	8.15 p.m.
24	National Isolated Power Plant Association	E. Fieux	8.00 p.m.
26	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.
May			
4	Blue Room Engineering Society	W. D. Sprague	8.00 p.m.
9	American Society of Mechanical Engineers	C. W. Rice	8.15 p.m.
11	Illuminating Engineering Society	P. S. Millar	8.00 p.m.
11	Institute of Operating Engineers	M. W. Rice	8.00 p.m.
16	New York Telephone Society	T. H. Lawrence	8.15 p.m.
16	American Institute of Electrical Engineers	R. W. Pope	8.15 p.m.
17	American Railway Association	W. F. Allen	10.00 a.m.
19	New York Railroad Club	H. D. Vought	8.15 p.m.
22	National Isolated Power Plant Association	E. D. Fieux	8.00 p.m.
24	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.
30—June 2	National Electric Light Association	T. C. Martin	all day

OFFICERS AND COUNCIL

PRESIDENT

E. D. Meier...New York

VICE-PRESIDENTS

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Terms expire at Annual Meeting of 1911

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E. M. Herr...Pittsburg, Pa.
H. H. Vaughan ....Montreal, Can.

Terms expire at Annual Meeting of 1912

MANAGERS

H. L. Gantt...New York
I. E. Moultrop..Boston, Mass.
W. J. Sando...Milwaukee, Wis.

Terms expire at Annual Meeting of 1911

H. G. Stott...New York
James Hartness..Springfield, Vt.
H. G. Reist...Schenectady, N.Y.

Terms expire at Annual Meeting of 1912

D. F. Crawford..Pittsburg, Pa.
Stanley G. Flagg, Jr..Philadelphia, Pa.
E. B. Katte...New York, N. Y.

Terms expire at Annual Meeting of 1913

PAST-PRESIDENTS

Members of the Council for 1911

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Robert M. Dixon...New York

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Calvin W. Rice...........................29 West 39th Street, New York

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Jesse M. Smith

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Francis Blossom (2), *Chairman*
Edward Van Winkle (3)
Bernard V. Swenson (1)
H. R. Cobleigh (4)
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LIBRARY

Leonard Waldo (1), *Chairman*
Chas. L. Clarke (3)
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E. G. Spilsbury (5)

MEETINGS

L. R. Pomeroy (1), *Chairman*
H. de B. Parsons (3)
Chas. E. Lucke (2)
Willis E. Hall (4)
C. J. H. Woodbury (5)

MEMBERSHIP

Francis H. Stillman (1), *Chairman*
Hosea Webster (3)
George J. Foran (2)
Theo. Stebbins (4)
W. H. Boehm (5)

PUBLICATION

H. F. J. Porter (1), *Chairman*
Geo. I. Rockwood (3)
Fred R. Low (2)
Geo. M. Basford (4)
Chas. I. Earll (5)

PUBLIC RELATIONS

James M. Dodge, (5), *Chairman*
D. C. Jackson (2)
Robert W. Hunt (1)
J. W. Lieb, Jr. (3)
Fred J. Miller (4)

RESEARCH

W. F. M. Goss (3), *Chairman*
Ralph D. Mershon (2)
R. H. Rice (1)
Jas. Christie (4)
R. C. Carpenter (5)

Note.—Numbers in parentheses indicate number of years the member has yet to serve.

SPECIAL COMMITTEES
1911

On a Standard Tonnage Basis for Refrigeration

D. S. Jacobus — G. T. Voorhees
A. P. Trautwein — Philip De C. Ball
E. F. Miller

On Society History

John E. Sweet — Chas. Wallace Hunt — H. H. Suplee

On Constitution and By-Laws

Chas. Wallace Hunt, *Chairman* — F. R. Hutton
G. M. Basford — D. S. Jacobus
Jesse M. Smith

On Conservation of Natural Resources

Geo. F. Swain, *Chairman* — L. D. Burlingame
Charles Whiting Baker — M. L. Holman
Calvin W. Rice

On Identification of Power House Piping

H. G. Stott, *Chairman* — H. P. Norton
I. E. Moultrop — J. T. Whittlesey
F. R. Hutton

On International Standards for Pipe Threads

E. M. Herr, *Chairman* — Geo. M. Bond
William J. Baldwin — Stanley G. Flagg, Jr.

On Standards for Involute Gears

Wilfred Lewis, *Chairman* — E. R. Fellows
Hugo Bilgrim — C. R. Gabriel
Gaetano Lanza

On Power Tests

D. S. Jacobus, *Chairman* — L. P. Breckenridge — Edward F. Miller
Edward T. Adams — William Kent — Arthur West
George H. Barrus — Charles E. Lucke — Albert C. Wood

On Standardization of Flanges

A. C. Ashton — J. P. Sparrow
Wm. Schwanhausser — H. G. Stott

On Student Branches

F. R. Hutton, Honorary Secretary

Tellers of Election Officers and Members

Wm. T. Donnelly — Geo. A. Orrok — Theo. Stebbins

MEETINGS OF THE SOCIETY

THE COMMITTEE ON MEETINGS

L. R. Pomeroy, (1) *Chairman* H. de B. Parsons (3)
Chas. E. Lucke (2) Willis E. Hall (4)
C. H. J. Woodbury (5)

Meetings of the Society in Boston

Ira N. Hollis, *Chairman* I. E. Moultrop, *Secretary*
Edward F. Miller James D. Andrew
Richard H. Rice

Meetings of the Society in New York

Walter Rautenstrauch, *Chairman* Fredk. A. Waldron, *Secretary*
F. H. Colvin Edward Van Winkle
Roy V. Wright

Meetings of the Society in St. Louis

Ernest L. Ohle, *Chairman* Fred E. Bausch, *Secretary*
M. L. Holman R. H. Tait
John Hunter

Meetings of the Society in San Francisco

A. M. Hunt, *Chairman* T. W. Ransom, *Secretary*
W. F. Durand E. C. Jones
Thomas Morrin

Meetings of the Society in Philadelphia

Thomas C. McBride, *Chairman* D. R. Yarnall, *Secretary*
A. C. Jackson J. E. Gibson
W. C. Kerr J. C. Parker
James Christie

SUB-COMMITTEES OF COMMITTEE ON MEETINGS

On Machine Tools

Willis E. Hall, *Chairman* John Parker Ilsley
Walter Rautenstrauch

SOCIETY REPRESENTATIVES

1911

On John Fritz Medal

F. R. HUTTON (1)
CHAS. WALLACE HUNT (2)
HENRY R. TOWNE (3)
JOHN A. BRASHEAR (4)

On Board of Trustees United Engineering Societies Building

FRED J. MILLER (1)
JESSE M. SMITH (2)
CHAS. WALLACE HUNT (3)

On National Fire Protection Association

JOHN R. FREEMAN
IRA H. WOOLSON

On Joint Committee on Engineering Education

ALEX. C. HUMPHREYS
F. W. TAYLOR

On Advisory Board National Conservation Commission

GEO. F. SWAIN
JOHN R. FREEMAN
CHAS. T. MAIN

On Council of American Association for the Advancement of Science

ALEX. C. HUMPHREYS

NOTE.—Numbers in parentheses indicate number of years the member has yet to serve.

OFFICERS OF THE GAS POWER SECTION

1911

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R. H. Fernald

SECRETARY
Geo. A. Orrok

GAS POWER EXECUTIVE COMMITTEE

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G. I. Rockwood (1)
C. J. Davidson (1)
E. D. Dreyfus (1)
F. R. Hutton (2)
H. H. Suplee (3)
F. R. Low (4)

GAS POWER MEMBERSHIP COMMITTEE

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A. E. Johnson
F. S. King
A. F. Stillman
G. M. S. Tait
George W. Whyte
S. S. Wyer

GAS POWER MEETINGS COMMITTEE

Wm. T. Magruder, *Chairman*
W. H. Blauvelt
E. D. Dreyfus
A. H. Goldingham
Nisbet Latta
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OFFICERS OF STUDENT BRANCHES

INSTITUTION	DATE AUTHORIZED BY COUNCIL	HONORARY CHAIRMAN	PRESIDENT	CORRESPONDING SECRETARY
	1908			
Stevens Inst. of Tech., Hoboken, N. J.	December 4	Alex. C. Humphreys	W. G. H. Brehmer	J. G. Bainbridge
Cornell University, Ithaca, N. Y.	December 4	R. C. Carpenter	A. W. de Revere	D. S. Wegg, Jr.
	1909			
Armour Inst. of Tech., Chicago, Ill.	March 9	G. F. Gebhardt	C. E. Beck	F. H. Griffiths
Leland Stanford Jr. University, Palo Alto, Cal.	March 9	W. R. Eckart	H. H. Blee	E. L. Ford
Polytechnic Institute, Brooklyn, N. Y.	March 9	W. D. Ennis	A. L. Palmer	R. C. Ennis
Purdue University, Lafayette, Ind.	March 9	L. V. Ludy	L. Jones	H. E. Spvoull
University of Kansas, Lawrence, Kan.	March 9	P. F. Walker	W. H. Judy	L. L. Brown
New York Univ., New York City	November 9	C. E. Houghton	Harry Anderson	Andrew Hamilton
Univ. of Illinois, Urbana, Ill.	November 9	W. F. M. Goss	F. J. Schlink	E. J. Hasselquist
Penna. State College, State College, Pa.	November 9	J. P. Jackson	W. E. Heibel	G. M. Forker
Columbia University, New York City	November 9	Chas. E. Lucke	F. T. Lacy	J. L. Haynes
Mass. Inst. of Tech., Boston, Mass.	November 9	Gaetano Lanza	Morell Mackenzie	Foster Russell
Univ. of Cincinnati, Cincinnati, O.	November 9	J. T. Faig	H. B. Cook	C. J. Malone
Univ. of Wisconsin, Madison, Wis.	November 9	H. J. B. Thorkelson	F. B. Sheriff	L. F. Garlock
Univ. of Missouri, Columbia, Mo.	December 7	H. Wade Hibbard	F. T. Kennedy	Osmer N. Edgar
Univ. of Nebraska, Lincoln, Neb.	December 7	C. R. Richards	W. J. Wholenberg	W. H. Burleigh
	1910			
Univ. of Maine, Orono, Me.	February 8	Arthur C. Jewett	A. H. Blaisdell	W. B. Emerson
Univ. of Arkansas, Fayetteville, Ark.	April 12	B. N. Wilson	W. Q. Williams	H. W. Barton
Yale University, New Haven, Conn.	October 11	L. P. Breckenridge	ClaytonDuBosque	W. Roy Manny
Rensselaer Poly. Inst., Troy, N. Y.	December 9	A. M. Greene, Jr.	G. K. Palsgrove	H. J. Parthesius
	1911			
State Univ. of Ky., Lexington, Ky.	January 10	F. P. Anderson	G. C. Mills	H. L. Moore
Ohio State University, Columbus, O.	January 10	W. T. Magruder	H. A. Shuler	H. M. Bone
Washington, Univ., St Louis, Mo.	March 10			F. E. Glasgow